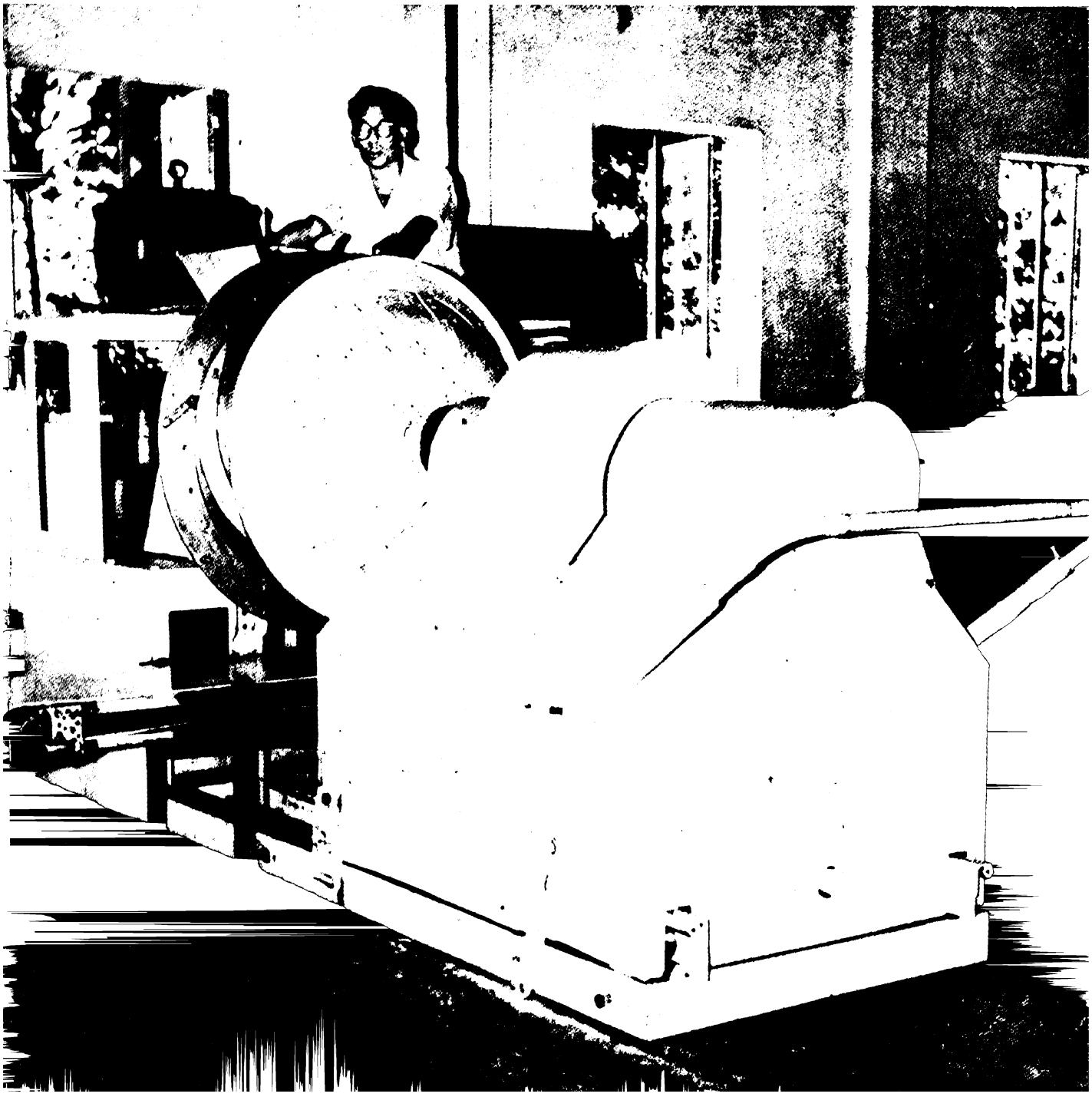
ANNUAL SCIENTIFIC REPORT

1969-70

TEA RESEARCH ASSOCIATION, CALCUTTA



Front Cover : Disc Roller under development at Tocklai

TEA RESEARCH ASSOCIATION

Annual Scientific Report

(1st April 1969 to 31st March 1970)

Published by
TOCKLAI EXPERIMENTAL STATION
JORHAT-8, ASSAM, INDIA
1970

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Contents

Director's Report

(1st April, 1969 to 31st March, 1970)

ORGANISATION

On the 31st March, 1970 the Senior Staff consisted of :—

Directorate :
Director
D. H. Laycock, M. B. E., M. Sc., A. I. C. T, A.

Deputy Director
S. K. Dutta, B. Sc. Hons. (Bom), B. Sc. (Wales)

Administrative & Finance Controller
M. K. Choudhuri, B. Com. (Cal), A. C. A.

Accounts Officer
S. Mazumdar, B. Com. (Cal), A. C. A.

Station Engineer
G. B. Singh, A. M. I. S. E.

Soil Chemistry Department :
Soil Chemist
S. K. Dey, B. Sc. (Cal), Assoc. I. A. R. I.

Botany Department :
Senior Botanist
D. N. Barua, B. Sc. (Cal), Ph. D., (Cantab.)

Plant Physiologist
W. Hadfield, B. Sc. Hons. (Liv.)

Plant Breeder
H. P. Bezbaruah, M. Sc. (Gau)

Agriculture Department :
Agronomist
F. Rahman, M. Sc. Ag., (Bihar), Ph. D. (I. A. R. I.), New Delhi.

Entomology Department :
Entomologist
B. Banerjee, M. Sc. (Cal), M. S. (S. Illin), Ph. D. (London).

Mycology Department :
Mycologist
G. Satyanarayana, B. Sc. Hons., (Andhra) Ph. D., (Mad), F. B. S.

Pesticide Department :
Pesticide Testing Officer
T. D. Mukerjea, B. Sc. (Alhd), Ph. D. (London) Assoc. I. A. R. I.

Biochemistry Department :
In-Charge
S. Chakraborty, M. Sc., Ph. D.

Manufacturing Advisory & Tea Tasting Department :
Manufacturing Adviser & Tea Taster
R. Choudhury, B. Sc. (Cal)

Second Tea Taster
M. R. Patel

Third Tea Taster
R. P. Basu

Engineering Development Department :
Senior Research Engineer
D. N. Barbora, B. Sc. Mining (Banaras) M. Sc. Mech. Eng. (London) D. I. C.

Second Research Engineer
T. C. Barua, B. Sc. Hons. (Gau), B Sc. Mech. Eng. (Banaras,) M. Sc. Mech. Eng. (Manchest)

Statistics Department :
Statistician
A. K. Biswas, M. Sc. (Gau).

Advisory Department:
South Bank Assam
Advisory Officer
P. C. Sharma, M. Sc. (Banaras), Ph. D. (London), F. L. S.

Advisory Officer (Designate)
B. C. Barbora, B. Sc. Ag., M. Sc., (Agronomy)
I. A. R. I.

Advisory Officer (Designate)
J. Chakravartee, M. Sc. Ag. (Gauhati)

North Bank
Advisory Officer
H. Mitra, B. Sc. (Cal).

Cachar
Advisory Officer
T. K. Ghosh, B. Sc. Ag. (Pat), Assoc. I. A. R. I., Ph. D. (Cornell)

West Bengal
Chief Advisory Officer
W. J. Grice, M. A. Dip. Ag. (Cantab)

Advisory Officer (Dooars)
S. Basu, B. Sc. Ag. Hons. (Delhi), Assoc. I. A. R. I.

Advisory Officer, (Darjeeling & Terai)
S. K. Sarkar, B. Sc. (Cal), B. Sc. Ag. (Banaras)

West Bengal Experimental Station : Mal
Officer In-Charge
N. B. Chanda, M. Sc. (Dac), Ph. D. (Edin).

SENIOR STAFF MATTERS

(**a**) **Appointment :** Dr. (Maj.) S. W. Rahman joined as the Resident Medical Officer on the 28th July.

Mr. J. Chakravartee joined as an Advisory Officer (designate) on the 3rd October.

Mr. R. P. Basu joined as a Third Tea Taster on the 6th October.

Mr. S. K. Dutta was appointed Deputy Director with effect from 21st October.

(**b**) **Transfers :**
The following Officers were transferred during the year as indicated.

Name	From	To
Dr. F. Rahman	Darjeeling	Tocklai
Mr. S. K. Sarkar	Tocklai	Darjeeling

(**c**) **Retirement :** Mr. S. B. Deb, Biochemist retired from the Association's service on the 30th June. Mr. S. C. Barua 2nd Agriculturist retired on the 5th July.

TRAINEES

Nine trainees sponsored by member/non-member gardens and the Tea Board completed the one year Training Course. Besides these, 5 employees of different member gardens joined the Short-Term Training on Veg. Propagation out of which four completed the training during the year.

TOCKLAI CONFERENCE

The 24th Tocklai Conference was held at Tocklai on the 11th, 12th & 13th November '69. The Conference was attended by 95 visitors, who represented the various tea producers Associations and tea districts of North East India, and delegates from South India and Ceylon.

LECTURE COURSES

The following Lecture Courses were held during the year :-

(1) **Survey & Drainage Course : (1969)**
1st Course- 21st—25th April 13 planters attended
2nd Course -28th April- 2nd May 13 „ „
3rd Course—5th-9th May 14 „ „

(2) **Agricultural Chemical Course : (1969)**
1st Course -21st to 23rd July 27 planters attended
2nd Course—28th to 30th July 27 „ „

(3) **Factory Management Course :** (1969)
1st Course- 29th sept. to 3rd Oct.
21 planters attended
2nd Course—6th to Oct-10th
October-28 26 „ „

(4) **Surveying & Drainage Course : (1969)**

1st Course-1st-5th Dec.	20	planters attended
2nd Course-8th-12th Dec.	20	,, ,,
3rd Course-15th-19th Dec.	29	,, ,,

(5) **Agricultural Chemical Course : (1970).**

1st Course-9th-11th March	23	planters attended
2nd Course-16th-18th March	21	,, ,,

VISITORS

Some of the Visitors in addition to local planters who are listed below :-

Tribeni Prasad Singh, Addl. Secretary, Foreign Trade, New Delhi.
Prem Kumar, Dy. Chairman, Tea Board, Calcutta.
P. K. Kanoria—Vice Chairman, T. R. A.
B. L. Newar, President, T. A. I.
Guy B. Baird—The Rockefeller Foundation, New Delhi.
C. R. Pomerok—New Delhi, The Rockefeller Foundation.
P. H. Ady—St. Anne's College, Oxford.
R. D. Kennett—Plant Protection Ltd., Fernhurst, England.
R. S. Nag, I. C. I. (I) Pvt. Ltd., Calcutta - 1.
B. C. Biyani—Jayshree Tea & Industries Ltd.,
J. Blades—Ministry of Overseas Development, London.
P. L. Brazier—Brook Bond Ltd., London.
Om Kaul—Carritt Moran & Co., Ltd.
S. K. Dutta—Carritt Moran & Co., Ltd.,
Sanjit Gupta—Economic Analyst American Consulate, Calcutta.
John G. Morgan—New Guinea.
B. D. Nag Choudhury—Member Planning Commission, Government of India, New Delhi.
W. L. Scandratt—James Finlay & Co, Ltd., Toronto, Canada.
A. H. Holliday—James Finlay & Co., Ltd. Toronto, Canada.
J. M. Goodfellow—John Goodfellow & Co., Ltd., Canada.
Dr. Peter Tetenyi—Budapest, Hungary.
Pilleri George—Switzerland.
S. Parthasarathi—Tea Promotion, Tea Board, Calcutta.
Sukdev Singh—Director Punjab Agri. University, Punjab.
N. K. Anant Rao—Dean U. P. Agricultural University, U. P.
S. K. Mukey—Dy. Agric. Commissioner, I. C. A. R., New Delhi.
Dr. J. S. Kanwar—Deputy D. G., I. C. A. R., New Delhi.
Dr. T. S. Ghose—Director Jute Research Laboratory, I. C. A. R., New Delhi.
N. R. Muniswamy, M. P., New Delhi.
Ram Autor Sarma, M. P., New Delhi.
K. G. Deshmukh, M. P., New Delhi.
Tarakeshwar Pande, M. P., New Delhi.
K. Seshadri, Under Secretary, Parliament House, New Delhi.
M. K. Dutta, Plantation Officer, Tea Board, Calcutta
B. B. Baruah—Officer in-charge, Coal Survey Laboratory, Jorhat.
Dr. A. Lahiri—Director, Central Fuel Research Institute.
Dr. E. E. Donath—U. S. Technical Aid Expert.
O. P. Arye—The Economic Times, Calcutta.
M. J. Colbourne—Ross Institute, London.
Toshia Sugita—Japan.
T. Honmura—Japan.
R.L. Hards—Chairman, London Scientific Committee

Advisory Department—Assam

Extension Services : Planters were clearly more vitally concerned with various problems associated with increasing yield and quality. More interest was noticed on the Area Scientific Committee meetings held at different tea districts and managers meetings where planters of the district freely participate, became more popular.

Six courses on Surveying and Drainage were held during the year and planters who attended showed keen interest on the theory as well as the practical excercises. Four courses on Agricultural Chemicals were conducted by the Department.

Requests for advisory visits have been increasing steadily and more visits would have been made but for staff movements and shortages on the South Bank. Recommendations were in general followed with good results, but exceptions are present due to economic stress or Company policies. Specialists visits, requested particularly by old member estates, are growing in demand and visits by Specialists are most helpful.

A view of a lecture course

Besides routine problems, discussions during advisory visits were becoming more concerned with drainage, chemical control of weeds, bringing up young tea, cleft grafting and rehabilitation and replanting.

The districtwise number of advisory visits paid were as follows :-

Areas	Total Nos. of visits	Number of estates visited	Visits to Expts.	Visits to non member gardens
South Bank	202	179	21	1
North Bank	169	64	27	
Cachar	88	29	8	

The Deputy Director left for U. K. for a six months study tour on the 16th March, '70.

Crop Outturn

Increased crop yield was, in general, obtained in the South Bank and the North Bank over the previous year. However, less crop was obtained in the Nowgong area of the South Bank mainly due to lower rainfall and droughty conditions during the early part of 1969. Cachar produced less crop because of adverse weather conditions.

Field Management Practices

(a) **Drainage** : Planters are becoming increasingly conscious of the drainage problems of their estates and much advisory effort has been directed towards this end. In most estates the main difficulty is to find suitable outfalls and very often a main outfall is bunded or blocked at places along the course by labourers or outsiders for paddy cultivation. This causes a backflow of the excess water and even with an efficient drainage system inside the estate, waterlogged conditions are thereby created. In some estates with inadequate outfalls, the drainage water from tea areas has been pumped out with good results to *khetlands* below after making an isolation drain and a bund on the *khetland* side.

The importance of a grid level survey for preparing countour maps is being impressed upon Managements and this has been done by estates where funds permitted. Renewed planning and

execution of drainage patterns on an estate which has been neglected, involves large amounts of money and labour. Consequently estates are therefore phasing out their drainage improvement works with

Practical work on a lecture course on surveying and drainage

priority, first been given to the making and/or improving outfalls and main drains followed by perimeter and primary drains and finally subsidiary drains. It has been noticed that in sandy, sandy loam or loamy soils the drain sides often cave in due to insufficient side slopes being given and too small size of drains. The specifications for drain sizes based on a catchment basis, side slopes and gradients were calculated by the Department for some estates during the year.

Many estates in Cachar are realising the benefit of contour drains and contour bunds both for drainage and soil conservation. Also the provision of perimeter drains at the base of teela slopes has been introduced with great success during recent years.

(b) **Pruning Cycles :** The majority of the estates are following the three year pruning cycle of prune–deepskiff—mediumskiff. Some estates experienced a banjhi problem with medium skiffed tea which may have been due to the high frames of the bushes, too liberal plucking, skiffing at the wrong time and wrong level conditions. In Nowgong district it was observed that shoots in deep or medium skiffed tea went banjhi just below the intended tipping level due to adverse weather conditions. Under the circumstances, advice was given to remove the banjhis for one or two rounds under careful supervision and then to tip at the recommended levels in subsequent rounds of plucking once active regrowth had started. It was also observed in the North Bank, that on high and weak medium skiffed bushes a 5 cm tipping measure did not work well and shorter tipping measures of about 4 cm ($1\frac{1}{2}$") resulted in better control of the banjhi problem.

A number of estates preferred light skiffing to medium skiffing in the cycle, while a few others have gone over to a four year cycle, of prune–deep skiff-medium skiff–light level off skiff. The longer pruning cycle has been followed purely with the idea of getting more crop. On the other hand some estates are following a biennial cycle of prune–deep skiff to obtain better quality tea. At least two estates on the South Bank are following rigid annual pruning for fear of losing quality.

In some proprietory estates, particularly in Cachar, the severity of skiff unprune within a three year or longer pruning cycle varied considerably depending upon the susceptibility to drought and pest and disease. The lightest forms of skiffs, or unprune for one or two years in succession, have been tried where the major criterion is increased crop.

Some estates in the South Bank tried unprune for one to two years, but preferred not to go for unprune again because of not obtaining expected results and also because of loss of quality.

(c) **Shade :** In many estates the shade status is rather poor. Advice was given to establish in poorly shaded areas, temporary shade of *Indigofera teysmanii* and many estates are doing this. On the other hand heavy shade has to be thinned out and while thinning out, it is preferable to lop only one side of the trees in a particular row and to follow the same pattern of thinning in the other rows for getting better and uniform shade.

Amongst the permanent shade trees, *A. odoratissima*, *A. lebbek*, *Derris robusta*, *A. lucida* and *Dalbergia sericea* continue to be dominant. *Acacia lenticularis*

has recently been introduced and is gaining popularity particularly on the North Bank. Planters have been discouraged from using *A. chinensis*, *A. procera* and *A. lucida* due to the high incidence of canker in these species. The advisory officers, during their visits, stressed the necessity of timely spraying shade trees against pests and diseases.

Planting of *Indigofera teysmanii* at a closer spacing of about 1.5 m to 2.5 m apart has been suggested for virgin or replanted areas instead of a green crop. Later on, the shade can be thinned out by removing alternate trees by which time the permanent shade trees will also be planted out.

(d) **Cultivation and Weed Control :** In many estates depressions around the collar of the bushes have been noticed due to faulty cultivation practices. It is also a common practice in some gardens to make bunds between the tea rows with the cheeled material and this results in due course in the making of ridges and furrows in the tea section. Under both the conditions i. e., the depressions and the creation of ridges and furrows, temporary waterlogging conditions prevail and the bushes suffer from impeded aeration. Planters were advised to fill up these depressions during rounds of cheeling and the cheeled litters be spread evenly over the surface of the soil as a mulch.

The use of chemicals to control weeds has been steadily growing in all the three districts. The common weedicides used by the estates are Gramoxone, Tafapon Bladex Q, (Dalapon), 2,4-D, Simazine, Karmex + Gramoxone cocktail. Tafapon + 2, 4-D mixture for the control of various types of grasses and broad leaved weeds has recently been recommended. Mikania can be controlled efficiently by using 2,4-D at our recommended doses. *Borreria hispida* (Bagracote) and *Spermococe ocymoides* are found to be somewhat resistant to Gramoxone and under such circumstances 2,4-D at 0.5—0.75 kg (a.i)/ha at intervals between Gramoxone applications has been found to give good control of the weed. Some estates are extensively using 2,4-D at 0.5—0.75 kg (a. i)/ha to control Bagracote and other broad leaved weeds with satisfactory results.

Better control of weeds was obtained by mixing a sticker (e.g. Tenac) or a spreader (e.g. Teepol, SNID PGN etc.) at 1 part of the chemical to 500 parts of the spray fluid on cloudy and sunny weather respectively, with some of the herbicides.

With the increased use of weedicides young tea areas are cleaner in many estates than ever before.

(e) **Manuring :** Many estates are applying phosphate and potash at 20 kg and 40 kg/ha respectively to one third of their estate every year besides the usual basic dose of nitrogen. Advice was given to apply phosphate and potash in the year of pruning. The rate of nitrogen application has been increasing where estates are not financially handicapped. Many estates have preferred to apply nitrogen in two split doses.

High levels of potash were tried in plots sited all over Assam in an attempt to induce magnesium deficiency symptoms. On the contrary, no magnesium deficiency symptoms were observed but good responses to potash application in terms of crop outturn were noticed, particularly on the South Bank. A few estates were subsequently advised to try potash at about 180 kg/ha and it will be interesting to see the results of these trials at the end of the 1970 crop season.

Medium pruned tea has been recommended to be manured with a N. P. K. 2 :1 :2 Y. T. D. mixture at the rates of 60 : 30 : 60 to 90 :45 :90 kg/ha depending upon the growth and vigour of the bushes. If necessary extra nitrogen only, may be applied to vigorous sections.

(f) **Plucking :** A new method of bringing up young tea under trial, has been found to give very promising results. Under this system the tea is centred out within a few weeks or months following transplanting i. e., as soon as these are clearly established in the field. The tea is thereafter tipped at 55 cm from the ground and plucking continued at that height untill a full plucking table is formed at this level. In this manner the plucking table should be raised intermittently in the first, second and third

year from planting without doing any form of pruning or skiffing. Normally there will be no need to raise the plucking table more than two/three times during each year and by the end of third year the plucking table will be at between 80-90 cm from the ground level when the bushes will be pruned at anything between 55-60 cm from the ground. Under this system the tea should be kept clean at all times and weeds kept under chemical control. Drainage shade and mulching should be adequate. Manuring should be as recommended vide T. E. Sl. No. 9/5 filed under D. 1. This system is being tried by many estates and firm results will be known and in the next following years.

The standard of plucking in general has improved in many gardens. Some estates are trying the stepped-up method of plucking i. e., the bushes after a light prune are first tipped and plucked to the janam at 10 cm above the level of pruning and then the plucking table is further raised by another 10 cm in early August. It has been reported that by the stepped up method of plucking more quantity of quality crop is obtained.

(g) **Other Field Management Practices**

Advice was also sought on nursery technique to both clones and seeds, spacing of tea, green crops and cover crops, rehabilitation crops, maintenance of clonal multiplication plots, cleft grafting and mulching.

On a few estates, young tea plants died due to heat damage caused by keeping the mulching material close to the collar of the plants. Planters were advised to keep the mulching material 8 - 10 cm away from the collar of the plants to avoid possible heat damage.

Pest and Disease Control

Red spider continues to be a major pest in some estates in the South Bank, North Bank and Cachar. Those estates who have followed advise on prophylactic spraying have been able to control the mite to a considerable extent.

Scarlet and purple mite were reported by a few estates in the South Bank, North Bank and Cachar. In the North Bank purple mite was widespread

The degree of mite control depended on the efficiency of spraying and type of acaricides used. Good results were obtained by using Tedion, Ethion, Hexamition and Trithion. Trithion besides being cheaper gave very effective control of red spider, purple and scarlet mites. Ethion was equally effective. Morocide worked well in the North Bank against purple and scarlet mites.

Looper caterpillar attack was reported by a few estates on the South Bank, and the pest posed a threat to some areas in the North Bank where it was found to feed heavily on *Indigofera teysmanii* shade trees. red slug caterpillar and red borer were reported by a few estates in the North Bank. Aphids, helopeltis and green flies appeared as minor pests in all the three districts.

Red rust has increased in many estates in the South Bank and Cachar particularly in young tea. The reasons for its prevalence were inadequate drainage, lack of shade, red rust susceptible green crops, general debility of plants in replanted areas and insuffcient chemical control. Advice was given on suitable copper fungicide spraying during April/May at fortnightly intervals and preferably two more rounds of the spray at monthly intervals in June July. In the South Bank it was found that on some estates the incidence of red rust has decreased by heavy manuring with potash.

Black rot incidence was heavy in many estates from July to September on the North and South Banks. The disease was controlled to a great extent in some estates by regular spraying (prophylactic and palliative with copper fungicides and by thinning out of shade where it was too heavy.

In many instances, pests or diseases could not be controlled by estates due to inadequate spraying equipment. More and more estates are going in for power spraying and often advice is sought for the

right kind of power sprayer to be purchased. For this purpose a scheme for testing and certifying spraying equipment was started at Tocklai last year. The indigenously manufactured engine that is being used in the majority of sprayers, needs constant attention and it was felt by many planters that facilities for repairing power sprayers and obtaining of spare parts are inadequate in the tea districts.

Extension, Uprooting and Replanting

In estates where land is available for extension, managements have usually preferred extension to replanting. Where land for extension is not available, estates have taken up replanting programmes, particularly after the introduction of the Replanting Subsidy Scheme of the Tea Board. In many cases, however, sufficient time has not been allowed for the rehabilitation of the uprooted land nor has deep cultivation like sub-soiling been done prior to replanting. On the other hand where sub-soiling has been done it has gone down to about 45 cm only. Soils have been analysed and advice on rehabilitation measures sought and given. The Advisory Officers emphasised the importance of using powerful tractors (50 h. p. or more) for sub-soiling and stressed that rehabilitation crops like Guatemala or Pusa Giant Hybrid Napier grass or *Mimosa invisa* pays in the long run. In highly acidic soils to the rehabilitation crop application of lime has been advocated at 2 tonnes per hectare. Where these suggestions were followed satisfactory results have been obtained.

In the North Bank, replanting was estimated at between 3-4% and extension planting at about 2% of the total tea estate area. There has been a growing tendency for uprooting and replanting in the South Bank and Cachar but not much attention has been given to proper rehabilitation and deep cultivation.

Closer spacing in single or double hedges has been advised for replanted areas. Emphasis is being given on the proper laying out of drainage patterns and establishment of shade prior to replanting. It has also been advised to plant estate waste lands with Guatemala or Pusa Giant Hybrid Napier grass for obtaining materials for mulching.

Recommendations were made for use on replanted areas, seeds of Manipuri kinds of tea such as Dangri, Rajgarh, Stock 203 or clones like TV. 1 and TV. 9.

A locally fabricated subsoiler blade (leg) designed to penetrate to a depth of 90 cm

Agricultural Machinery

In many estates sub-soiling is being done with tractors of 35 - 40 h. p. with the result that the depth of penetration obtained is only about 35-40 cm. Whereas estates using tractors of 50 h. p. or above have been able to do sub-soiling to depths of about 60 cm. If sub-soilers normally designed to penetrate to 90 cm have to be pulled by a single tractor with a direct linkage, the prime mover will have to be of about 100 to 120 h. p. Such tractors are not, firstly manufactured in India; secondly, even if they could be imported they would be very expensive- about Rs. 1000/- per h. p. and thirdly, they would be too

heavy for most estates and secondary roads and bridges. Therefore, attempts were made to see whether by using two or more of the medium sized tractors available in the country, the sub-soiler can be worked upto a depth of about 90 cm. This was tried by using two 50 h. p. Hindustan tractors on a tandem by toeing with chains, and it was found that when the moisture of the soil was at its field capacity the two tractors were able to pull the sub-soiler without apparent difficulty down a depth of about 80 cm and the movement of the sub-soiler was approximately 42 m per minute. When a third tractor of 35 h. p. (Ferguson) was added the sub-soiler was pulled with extreme ease and the rate of its movement was 45 m per minute. This means that sub-soiling 60 cm apart, one way only, using two medium sized tractors (of 60 h. p.) one should be able to cover one hectare a day on an 8 hour working day.

The sub-soiling blade designed for a penetration of 90 cm was made in a local work-shop.

Meetings

Area Scientific Committees : There are three Area Scientific Committees on the South Bank, two on the North Bank and one in Cachar. During the year a total of 17 meetings were held as under :-

South Bank	East	...	3
	Central	...	2
	West	...	2
North Bank	East	...	3
	West	...	3
Cachar	...	...	4

Growing interest of the Committee members as well as planters in general was noticed in the meetings in all the areas. Committee meetings are generally preceeded or followed by a general Planters' meeting. These meetings have been well attended and planters were keen to bring out their problems for discussion. There have been increasing demands for such meetings particularly from the South Bank East area.

Advisory Department—West Bengal

GENERAL

During the year Dr. F. Rahman, Advisory Officer, Darjeeling and Terai was transferred to Tocklai to take over the post of Agronomist, and the vacancy so caused was filled by the arrival of Mr. S. K. Sarkar from Tocklai. Dr. N. B. Chanda remained in charge of the Soil Testing Laboratory at Mal and completed his special assignment of collecting yield and field management data from Member estates in the Dooars and the Terai.

VISITS

The Advisory Officers who concentrated on routine touring, made all efforts to offer their services to every Member estate two to three times during the year. The total number of Member estates in West Bengal on 31/3/70 was 172 and during the year 225 visits were made to 133 Member estates, therefore 39 Members did not make use of our services. The table below gives the break down of the visits made in each district.

District	No. of visits	No. of members visited	No. of member estates in District
Dooars	118	69	102
Darjeeling (including Sikkim)	75	48	52
Terai	32	16	18
Total	225	133	172

There were 71 less visits in the year under review in comparison to the previous year. The reasons for this are three-fold i. e.

(a) The 17 day general strike which effected all estates in West Bengal and the uncertain political situation experienced in West Bengal in 1969/70.

(b) The change of Advisory Officers in Darjeeling.

(c) The Chief Advisory Officer was away on U. K. leave for 5 months and the Advisory Officer, Dooars on privilege leave for 3 months

In the last report, mention was made of the problem caused by Members asking Advisory Officers to visit their estates for special visits. This year the number of special requests declined and this enabled the Advisory Officers to concentrate on their routine tours which was of great help.

It is satisfying to be able to record that our advice has been generally followed, however, we have been told on occasions that implementing our advice has not always been possible due to labour unrest. Due to the latter situation, advice sought has been more on the day to day routine problems, rather than on matters concerning the future. On several occasions we have been informed that even with the best will in the world, implementing our advice is quite impossible and many managers have had to be content with an unsatisfactory compromise.

As this is a Scientific report it is not the place to record details of the labour problems faced by the Industry in West Bengal in 1969. However, it would be well to point out it is our opinion that in view of the great steps ahead made by Tea in other countries, India can ill afford anything that is going to hamper its progress in this respect. Co-operation from labour to ensure that modern scientific techniques are implemented is essential to the well being of the Industry as a whole and the labour in particular.

In general all districts had a good start and were ahead in crop until the 17 day general strike started on 18th August, 1969. This was a grievous blow to the already distressed tea industry, resulting in a big loss in crop which it could ill afford. Advice on the skiffing operations to follow after the return to work of the labour was circulated to all Member estates in W. Bengal, where this advice was followed the crop loss was kept to the minimum.

The Deputy Director and M. A. T. T. made special visits to study the situation arising from the 17 day strike, and their suggestions were also circulated to the Member estates.

The principal points arising from advisory work during the year are discussed briefly below.

1. Field Management Practices

(1) Soil Management

(**a**) **Land Planning :** This Department continues to stress the importance of land planning. However, the writer does not know of one estate that has had a complete level survey undertaken and uprooting for replanting is not being done on a planned basis. We are still making every effort to obtain aerial photographs to help in this direction, and while some progress has been made it will be sometime before land planning will be possible with the aid of aerial photographs. Estates cannot afford to wait, and complete level surveys are essential before a planned uprooting and replanting programme is possible.

Cleft grafting—growth at Jiti T. E. grafted in February, 1967

(**b**) **Drainage :** A well designed drainage system is dependent on knowing the catchment area with which each main drain has to cope and then dividing up each main catchment area into smaller and smaller areas each having their own self contained system of drains. No estate is drained on this principle and it will take many years before this is possible. However, a start should be made without further delay and level surveys are an essential preliminary for a planned system; coupled with uprooting for replanting on a topographical basis.

There is no doubt that much more importance is being attached to drainage and our advice is being sought on this topic more and more often. However, we are rarely in a position to give the best advice for level surveys of the areas to be drained are not always available and to make matters worse, more often than not the area to be drained has already been planted. We have, therefore, stressed time and again that a drainage plan should be made *before* the tea is planted and the tea should be planted to fit in with the drainage plan.

This method ensures water conservation in time of water shortage and the removal, under control, of excess water in times of heavy rainfall. Soil erosion is automatically checked and as the actual size of each drain can be calculated and as the drains will be following the natural lie of the land, their maintenance will be reduced to a minimum.

Here is a convenient place to record that contour draining in tea that has been planted in straight lines is not the correct method of draining. These contour drains will require frequent cleaning, for storm water will run into them out of control and will therefore be carrying silt. This will be a continual problem, particularly when the tea is young, in pruned years and if herbicides are used for weed control.

(**c**) **Mulching :** The importance of mulching has been stressed again and again. Mulching protects the soil from the physical action heavy rain and hot sun has on the structure, conserves moisture and also has some nutrient advantages. The high percentage of torrential rain that falls during the mon-

A converted seed bari — grafted 1968

A converted seed bari — grafted 1968

soon, the droughty conditions that are common during the cold and hot weathers are common features of tea areas in West Bengal, and make it very essential to have a mulch covering throughout the year, especially in young tea which has not yet fully covered the ground. Estates have repeatedly been advised to establish grasses such as Guatemala, and Pusa Giant Hybrid Napier on all vacant areas and areas unsuitable for tea, i. e. areas which have unsuitable soil acidity and/or shallow top soil, and areas which are low lying or too steep, in order to readily obtain material for mulching in tea areas. It is heartening to note that a number of estates have made really good efforts in this direction.

It has been pointed out on a number of occasions that whenever labour is available they should be employed for mulching.

Vacant areas covered by mulch crops
Hantapara T. E.

Vacant areas covered by mulch crops
Longview T. E.

(d) Cultivation and Weed Control : The use of herbicides is becoming more and more popular and large scale use of herbicides has become a regular

feature in a number of estates in the Dooars; in the Terai and Darjeeling, however, herbicides are still mainly on trial. This is understandable in Darjeeling where complete weed control by herbicides could easily result in serious erosion. Trials to investigate the erosion hazard in tea planted up and down the slope following the complete control of weeds with herbicides in the monsoon months have been laid out. It is hoped that firm recommendations on the use of herbicides in Darjeeling will be possible after the results of the trials have been analysed.

Estates that have been using weedicides for several years have found that there is a considerable reduction in the cost of chemicals each year, for the number of rounds necessary to ensure weed control becomes less. By far the most widespread herbicide used is Gramoxone. However, we have been advising the use of 2, 4-D at 0.5 to 0.75 kg active ingredient per ha in areas where Bagracote jungle and Mikania are serious problems. Dalapon is also more widely used where thatch and other grasses are a problem.

There is a general tendency to wait for too long to spray the first dose of post-emergence herbicides. It has been stressed that the first spraying should be given as soon as after the weeds germinate as possible, as these herbicides are more effective on actively growing immature weeds.

The use of Simazine as a pre-emergence herbicide has become popular in V. P. nurseries, and has been found to keep weeds under control for several months after planting the cuttings.

Where manual cultivation is still undertaken advice has been given against the common practice of cheeling in the dry months of January-March. We advise that as far as possible a cheel be given before the soil dries out, the weeds flower and set seed i. e. towards the end of October and that the cheeled litter be spread evenly over the surface of the soil as a mulch. When cheeling is not possible at the end of the season then it is best to sickle the weeds before they set seed and leave uncheeled until weed growth starts the following year.

2. Pruning & Plucking

(a) **Pruning Cycles :** In the Dooars and Terai a three year pruning cycle of light prune, deep skiff and medium or light skiff continued to be the most popular. Levelling-off skiffing in the cycle is becoming less popular because of difficulty in coping with plucking during the big flush in the early season. Furthermore, levelling-off skiffed sections are very prone to drought effects and red spider infestation, and there is some doubt over the quality of tea made from areas that have had a level skiff. In drought prone sections a two year cycle of light prune and deep skiff has usually been advised. A few estates have introduced four year pruning cycles. A general increase in crop is possible by increasing the length of the pruning cycle, provided that adequate steps to control mites and strict attention to the plucking level are taken. One area where this appears to be an exception is in the South Terai for in this area light skiffed teas tend to give lower crop than pruned or deep skiffed teas. This is due to the fact that in that area rain before the end of May or early June is very rare.

In Darjeeling there has been a continued trend to change to longer pruning cycles and this, by and large, has resulted in an increase in crop. However, the problem of plucking the leaf in the heavy flushing month of April and the second flush period will be excentuated with the longer cycles and so careful thought is necessary before changing the established pruning cycle. One way of overcoming this problem is to introduce the heavier skiffs, particularly a deep skiff, into the longer cycles and this has been advised on a number of occasions.

Skiffing following each flush, to remove banjhis in unpruned tea, is becoming fairly common in Darjeeling and is advised where labour is not available to pluck the banjhis. It is always stressed that plucking is better than skiffing, but when plucking is not possible then skiffing is a good second choice and is very much better than leaving the banjhis on the bushes.

Following the general strike in all tea estates over the period 18th August to 2nd September circulars were issued to all Members detailing our advice on the skiffing treatment to give. There is no doubt that where skiffing was done according to our advice,

crop loss was kept to the minimum. Whenever skiffing has to be resorted to in the rains the best place to skiff is at the last plucking level; any skiff above or below this level will result in a crop loss that is larger than necessary.

(**b**) **Plucking :** It has been stressed in all West Bengal districts that with the introduction of longer pruning cycles, it is now even more essential to give a full 18-20 cm tipping measure in the pruned year. It is unfortunate that many estates still continue to tip to a lower measure in the pruned year. We have stressed on a number of occasions that this practice will lead to a gradual loss in crop and creates difficulties during the skiffing operations during the cycle.

The correct height of tipping is a prerequisite for obtaining increased yield from skiffed tea, especially from deep and medium skiffed tea, but this important fact is often overlooked. If a drought intervenes in the early part of the year, as often happens in West Bengal, the internode length becomes shorter than usual and the first banjhi horizon is therefore lower. Under such circumstances, the tipping measure should be reduced to coincide with the height the bushes have gone banjhi. If this is much lower than the usual height then the level can be raised after the second flush. A number of estates have obtained satisfactory results by adopting this method of tipping.

By and large most estates in the plains areas manage to pluck on a fairly regular round and advice on plucking is mainly confined to new Members. However, in Darjeeling, plucking rounds becoming out of hand is more often the rule than the exception. This fact has been reported in the last two annual reports and continues to be a problem on which advice has to be given. We continue to stress that a regular plucking round is absolutely essential to harvest the maximum crop.

The banjhi problem has been discussed on a number of occasions and we have pointed out that banjhiness during the season is natural and the best way of checking these periods of dormancy is to pluck well. There is no doubt that those who complain of excessive banjhis are normally not plucking hard enough on a regular round.

3. Planting

(**a**) **Infilling :** The importance of infilling has been particularly stressed during the year. One of the reasons for the overall yield in the Dooars and Terai not increasing, may well be due to the fact infilling has been overlooked. Infilling if properly done can significantly increase yield in a very short period, as is evident from the results obtained by an estate where the yield of a section shot up to nearly 2000 kg/ha from 1350 kg/ha, in the third year from infilling. A lot of pain and care must, however, be taken to help establish the infills, and the use of well-grown plants of a hardy jat or clone is always recommended. It is doubtful if many estates know exactly how vacant some of their mature tea areas are. We found, when laying out an experiment on infilling, that the percentage vacancies in the sections where the experimental plots were laid out was always 5 to 8%, and in one case over 10%, more than the vacancies shown in the estate records.

(**b**) **Extension :** Extension is confined to those estates where land is available and is more often than not on thatch and bamboo baries and scrub land. It is also being forced on some estates for fear of unlawful encroachment. There is a tendency to extend on land that is not completely suitable; this has been advised against and we have suggested that this land should be utilised for mulching crops instead. Where suitable land is available, however, we advise that extension be completed before replanting is undertaken.

(**c**) **Replanting :** As was predicted last year, there has been an increase in replanting due to the Tea Board's replanting subsidy scheme. As estates have to send soil sample reports with the application for the subsidy, and the results of the analysis of all soil samples of Member estates in West Bengal is routed through the Nagrakata and Darjeeling offices, we have a good idea of the area that is going to be replanted in the near future. It is interesting to note that most of the areas appear to be chemically suitable,

but it is often open to doubt whether they are physically suitable and we continually advise that a careful study of the profile, drainage and physical structure be made and only if all these factors are suitable should the area be replanted. We also stress, in the strongest possible terms, the need to rehabilitate under a recommended rehabilitation crop for a minimum period of at least two growing seasons.

There are very few replanted areas in the plains areas of West Bengal that are yielding more crop than the area before uprooting and these are a continual source of worry to both management and Advisory Officers. There are several reasons for this, but the main one is, without doubt, lack of rehabilitation. We have sufficient experimental evidence to show that at least two years rehabilitation is essential to ensure good development of the replanted tea. Estates that do not adequately rehabilitate their replanted areas are courting considerable trouble for the future. There is no easy way of rehabilitating soil once the tea is planted.

4. Propagation

(**a**) **Seed :** More and more estates are following our advice and using hardy *jats* for planting. Polyclonal Stock 203 is recommended, has been widely used and has been found successful. There are, however, still some estates where planting is being done with light leaf *jats* in spite of our strong recommendations against their use.

(**b**) **Vegetative Propagation :** Many more estates in the Dooars have reached the stage where all planting can be done with clones and we have continued to stress the importance of testing clones on estates before large scale planting is carried out with one particular clone. Routine advice on all aspects of V. P. work including cleft grafting has been given. By and large, satisfactory results are being obtained by estates, but in certain cases, poor results in the nurseries have been attributed mainly to insufficient soil acidity, waterlogging and heavy shade and measures have been suggested to overcome these difficulties.

Sun-scorch lesions are commonly observed in clonal multiplication bushes. Placing the pruning litter on top of the frame immediately after the prune has been suggested as a counter measure. Estates have also been advised to establish shelter belts around V. P. nursery areas and multiplication plots.

Two estates have converted their *jat* seed baris into clonal seed baris and one of them is expecting to harvest some biclonal seed in 1970 i. e. in about 2 years from grafting. Cleft grafting for rapid multiplication of clonal material is also becoming more and more popular.

5. Fertilizers

(**a**) **Nitrogen :** The general level of nitrogen applied, remained about the same in all districts for 1969 with the possible exception of Darjeeling where there was evidence that there was a general increase in Nitrogen level. Following the poor year in 1969 many estates where considering a reduction in nitrogen for the 1970 season and some in fact have decided not to manure at all. There is no doubt that more attention to detail at the time of application on many estates is necessary.

Foliar application of urea is becoming an established practice in nurseries in all districts and several estates have tried foliar application in unpruned mature areas with a view to increase the early crop.

(**b**) **Phosphorus & Potash :** There are still some estates which do not carry out our recommendation of manuring with P & K at the rate of 20 kg $P_2 O_5$ and 40 kg $K_2 O$ per ha every third year. We have been at pains to persuade these estates to follow this recommendation.

(**c**) **Mixtures :** Most estates follow our advice over the application of YTD to young tea. There is a tendency to reduce the NPK mixture advised for medium pruned areas in some estates. In Darjeeling our recommendations for NPK manuring of heavy pruned areas is generally followed.

6. Shade

(**a**) **Green Crop :** Our current advice is to remove green crop shade from young tea areas after one year. There is still a tendency to keep green crop shade in too long and this has been advised against on several occasions.

(**b**) **Temporary Trees :** *Indigofera teysmanii* continues to be the most popular temporary species. We have had to advise lopping to maintain the correct shade density on a number of occasions. It is not often appreciated that this species needs constant attention to maintain the correct shade density, when this is not done then the shade becomes dense and the tea suffers.

(**c**) **Permanent Shade :** Establishment and maintenance of permanent stand of shade continued to be an exasperating exercise. The importance of taking special care and pain to raise good nurseries has been emphasized again and again, so has the attention to detail at the time of transplanting. It has been our experience that if the shade trees can be given a good start they are in a better position to resist the onslaught of pest and diseases later.

Use of *Albizzia odoratissima* and *Albizzia chinensis* has been discouraged in view of their extreme proneness to various pests and diseases, in particular canker. *Acacia lenticularis* appears to be promising as a permanent shade tree and is becoming more and more popular. Other species that have been suggested are *Derria robusta*, *Dalbergia sericea*, *Dalbergia sisoo*, and *Albizzia lebbek* (in foothill estates). We have advised the use of mixed stands of shade.

The above comments apply to the plains estates, for we now believe that shade above an elevation of 1500- 2000 feet in Darjeeling is not necessary and estates above this elevation have been advised to remove shade.

7. Pests & Diseases

(**a**) **Pests & Diseases Bulletin :** This bulletin as usual was regularly circulated to all estates in West Bengal giving advice on pest and disease control, chemical weed control and availability of insecticides, fungicides, acaricides and herbicides, and has continued to prove a useful guide for control measures and is invaluable as a reference.

(**b**) **Red spider :** Red spider in the plains areas appeared to be under control until April, but an attack appeared in May. An interesting feature was the sharp rise in the incidence of the pest in pruned and deep skiffed tea. Could it be that prophylactic spraying was neglected in pruned and deep-skiffed sections? Defoliation was discontinued by large number of estates. True, this is a step in the right direction but timely prophylactic spraying must not be ignored if the object is to get an effective control of red spider. It has been stressed that money spent on spraying equipment and pesticides is money well spent and is certain to pay off handsomely in the long run. An estate in Kalchini area has reported that it spends about Rs. 65/- per hectare on prophylactic and palliative spraying against red spider, with excellent results. A wide range of good pesticides and acaricides and efficient spraying equipment is available on the market, and therefore there is no need for any estate to suffer a severe attack of any pest.

In Darjeeling, red spider was its usual active self and was serious on estates where control measures were inadequate.

(**c**) **Other Pests :** In the three West Bengal districts scarlet and purple mite did their fair share of damage. Red slug was serious in some areas and so was looper caterpillar. As usual the Advisory Officer in Darjeeling had to cope with the pest and disease problem more than other Advisory Officers; rarely does a report on a visit to a Darjeeling estate contain no mention of pests. Those that featured frequently were :- Scale insects, thrips and green flies . The damage caused by scale insects is now receiving more attention but the control of thrips and green flies generally does not receive adequate attention.

(**d**) **Diseases :** Red rust continues to be the most important disease in both tea and shade on the plains. Recent trials at Tocklai have indicated that spores of red rust are dispersed into the atmosphere for long periods after the conventional spraying of copper fungicides has normally stopped. Estates have therefore been advised to continue spraying upto July, but for spraying during the rains more persistent copper fungicides than those at present in use will be needed.

Black rot is also a major disease in tea but it can be kept under control by having the correct shade

density, knife cleaning out, and prophylactic and palliative spraying with copper fungicides.

In Darjeeling, Blister blight was severe in areas that were heavily shaded in July and the general strike allowed this disease to become serious in all mid to high elevation estates.

8. 1968 Darjeeling Disaster

A brief record should be made that our prediction that the District as a whole should harvest much the same crop off the smaller area in 1969 as in 1968 by more intensive management was proved correct. For by the start of the strike on the 18th August the District was ahead in crop and there is therefore good reason to believe that had there been no strike the 1969, crop would have been higher than in the previous year.

9. Yield Survey

As mentioned at the beginning of this report, Dr N. B. Chanda completed the collection of yield and field management data from Member estates. The mass of data has been handed over to the Statistics Department for analysis.

10. Power Spraying Demonstration

In Darjeeling 7 power spraying demonstrations were conducted in different Sub-districts from 1st to 6th December, 1969 in order to find out a suitable technique for spraying in the hilly areas. It was observed that spraying of two rows on both sides by swinging the nozzle gently was more convenient than spraying two or three rows on one side by keeping the nozzle at an angle of 45° in one direction (as has been suggested in the T. E. Serial No. 171 filed under I 4). In the former system the operators could spray more efficiently and areas left unsprayed were reduced. This is mainly due to the fact that most of the tea in Darjeeling was planted along the slope and the terrain is very uneven. The quantity of spray fluid required to cover one hectare varied between 160 and 200 litres with No. 2 nozzle of the 'Jawan' or 'Solo' sprayers. The time taken to spray one hectare varied between 3 to 4 hours. Dr. T. D. Mukerjea, Pesticide Testing Officer, Tocklai was present during these demonstrations which were attended by the Managers and Assistants.

In addition, four demonstrations for spraying supervisors and operators were conducted in Darjeeling between 24th and 30th March, 1970. These demonstrations were found very useful as in most of the cases the operators and mechanics were found not well conversant with the proper technique of spraying and the servicing of spraying machines. Dr. T. D. Mukerjea, Pesticides Testing Officer, Tocklai and the Borbhetta Mechanic conducted these demonstrations.

EXPERIMENTS

1. Experiments and other work at Nagrakata, H. Q.

At the start of this report it is appropriate to record the sudden and tragic death while on duty of P. P. Lama. Lama had served the Association for over eleven years and was responsible for the supervision of all work at Nagrakata, H. Q. including the Meteorological station. He was a willing, honest and hard working employee and will be greatly missed.

Like most other establishments in the Dooars we at Nagrakata had our labour problems in the year under review. Two gheraos took place and on both occasions the ring leaders were outsiders and those gheraoed were subjected to a tirade of abuse and threats. After each gherao an agreement was signed and all sub staff and labour in Nagrakata, Mal and Darjeeling are now paid according to the D. B. I. T. A. scales with cash compensation for fringe benefits. Since the second agreement was signed a satisfactory standard of work has been maintained .

The plots and land at the Nagrakata, H. Q. was level surveyed by Dr. N. B. Chanda and the Chief Advisory Officer.

Nearly 85,000 cuttings of Tocklai release clones were distributed to Members but this is a fall on the previous year, which is attributed to the fact that there was small demand for cuttings in the autumn period, mainly due to the aftermath of the general strike. In spite of a considerable reduction in prices

of clones for Members in Darjeeling, who suffered in the October 1968 disaster, the demand was generally poor.

Nearly 5300 scions of the seven clones making up the Stock 203 polyclonal seed were released to two estates who are converting *jat* seed baris. In addition scions as follows have been distributed : TV 13-100, TV14 - 45, TV15 - 25, TV16 - 65 and TV17-45.

Guatemala, Pusa Giant Hybrid Napier and Weeping Love Grass were released to Members. Darjeeling eatates, as a result of the 1968 disaster, received priority and the majority of the material available went to Darjeeling estates. A total of 8675 stems of Guatemala, 15,120 stems of Pusa Giant Hybrid Napier and 2,920 clumps of Weeping Love Grass were released to Member estates.

The Nanda Devi biclonal seed bari was infilled during the year. During the prolonged drought in early 1970 a fire spread in to the bari from outside and some 220 plants were destroyed.

The four replicates of the agricultural trial planted in 1967 and 1968 received routine treatment and is now established. Yield records are being recorded. The observation plots of the Mal clones are also established and sufficient leaf will be available for manufacture next season.

The first plots of the quality testing scheme were planted, 8 estate clones are under trial and in addition plots of 3 of our biclonal stocks have also been planted alongside and these will prove useful for demonstration.

One bush each of 10 of our release clones was carefully uprooted to determine the root depth. Briefly it was found that root depth and spread varied from clone to clone and that those that appeared hardy and drought resistant had a well developed root system with good penetration. Excellent root systems were found on clones TV10, TV11, TV16 and TV17. The root systems were measured and colour slides taken.

2. Clonal Proving Station, Darjeeling

(a) **Trial Planted 1967 :** Observations were made on growth of the 19 clones in this trial. Plotwise yield was recorded throughout the year and a total of 117 samples were manufactured towards the end of the 1969 season and the start of the 1970 season.

(b) **Trial planted 1968 :** Observations were made on the growth of the 8 clones in this trial and the plots were managed with the object of obtaining leaf for manufacture as soon as possible.

(c) **Trial planted in 1969 :** Observations were made on the growth of the 6 clones in this trial.

All the clones in these trials are being tested against two standards one is the Tocklai Biclonal Stock 378 (Nanda Devi) and the other leaf from a hybrid section.

(d) **Factory :** The building of the quarter and factory was completed . However manufacture was not possible in the factory due to problems over electricity and all samples were manufactured in the Ging Factory and we would like to record our appreciation for the excellent co-operation received in this respect from Ging Tea Estate.

3. Field Experiments on Estates

Short and Long term experiments have been continued in Member estates, these cover a number of projects such as; cultivation, shade, manuring, pruning, rehabilitation of soils, irrigation, clonal seed, reclamation of sub-acid soils, infilling and pests and diseases control. A complete list of Advisory Department experiments is given in Appendix A, and a list of experiments being conducted in co-operation with other Departments is given in Appendix B. The Chief Advisory Officer, West Bengal paid a total of 45 visits to these experiments. Brief details of the distribution of the experiments are given below:

(a) **Dooars :-**In the Dooars there are 19 Advisory Department experiments and 18 experiments conducted in co-operation with other Departments. 5 Advisory Department experiments, one long term experiment i. e. cultivation experiment at Chuapara and four short term experiments i. e. Urea Vs. Sulphate of Ammonia have been discontinued at the end of 1969.

(**b**) **Terai :-**In the Terai there are 3 Advisory Department experiments and two experiments conducted in co-operation with other Departments.

(**c**) **Darjeeling :-** In Darjeeling there are 14 Advisory Department experiments and 6 experiments conducted in co-operation with other Departments.

MEETINGS

All senior officers in West Bengal visited Tocklai twice during the year.

The following annual general meetings were attended.

(i) T. B. I. T. A. by the Chief Advisory Officer.

(ii) Dooars B. I. T. A. by the Chief Advisory Officer, West Bengal.

(iii) Darjeeling B. I. T. A. by the Chief Advisory Officer, West Bengal and Advisory Officer, Darjeeling.

(iv) I. T. P. A. by Dr. N. B. Chanda.

(v) T. A. I., North Bengal Branch by Chief Advisory Officer, West Bengal and Advisory Officer, Darjeeling.

The Chief Advisory Officer, West Bengal attended the only meeting of the T. R. A. Agricultural Sub-Committee held during the year in Calcutta.

Area Scientific Committees

The three Area Scientific Committees in Bengal held a total of 11 meetings, the Dooars and Terai Committees met 3 times each and the Darjeeling Committee 5 times. In addition the Sub-Committee set up by the Dj. A. S. C. to plan the joint meeting met twice. The Chief Advisory Officer attended five of these meetings.

Meetings when possible were arranged to coincide with visits of Tocklai officers to Bengal. There was always a free exchange of ideas and all meetings proved extremely helpful and improved the liaison between the planter and scientific staff.

A joint meeting of all Area Scientific Committees was held in Darjeeling at the end of February for three days. The original plan to hold this meeting in all areas of West Bengal could not be carried out as the Dooars Committee felt it could not plan a meeting in view of the political tension in the district. The meeting was therefore shortened to 3 days and confined to Darjeeling. 8 delegates from the other Area Scientific Committees and 8 Tocklai officers attended the joint meeting and all agreed that it was a great success. The delegates were shown round 5 tea estates, the Clonal Proving Station and attended a meeting with the Darjeeling Area Scientific Committee to which all Darjeeling planters had been invited. This meeting discussed problems peculiar to Darjeeling and a free exchange of ideas was had.

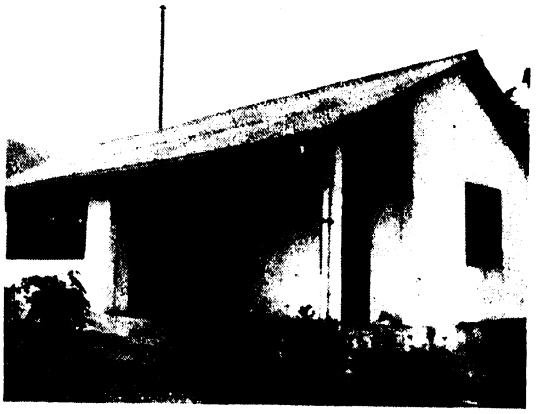
MISCELLANEOUS

Soil Testing

A total of 2598 soil samples were analysed during the year and of these 932 were for experiments.

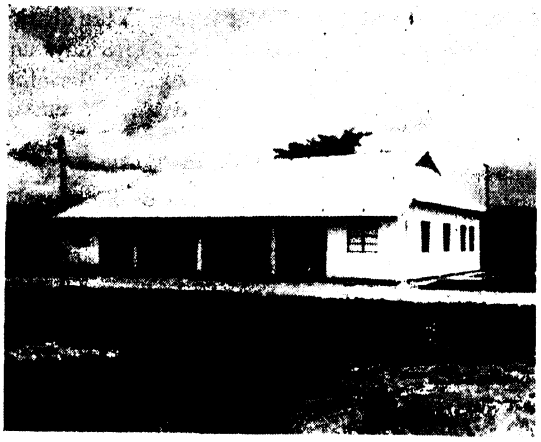
Visitors

As usual a large number of visitors visited the stations at both Nagrakata and Darjeeling. We were particularly pleased to welcome Messrs. N. Shanmuganathan, D. Kirtisingha and U. Pethiyagoda from T. R. I., Ceylon. They were shown six estates in the Dooars and Darjeeling and the



Ging Factory.

plots at Nagrakata and the Clonal Proving Station at Ging Tea Estate. It was also a pleasure to entertain Mr. J. C. Llewellyn from I. T. A. London and to show him round the Nagrakata Station.



New Office Block, Nagrakata.

Building and Land

A new house was rented in Darjeeling in which both the office and residence for the Advisory Officer are accommodated.

A start was made on building the miniature factory at Nagrakata. However this was stopped and work on building an office block was started instead. A generator house was completed.

Meteorological Station

Two fully equipped meteorological stations are maintained in West Bengal, one at Nagrakata H. Q. and the other at Nagri Farm Tea Estate in Darjeeling. Regular readings were recorded throughout the year.

Summary of Results

ADVISORY DEPARTMENT FIELD EXPERIMENTS

Brief summaries as at the 1st of April, 1970, of some of the experiments conducted by the Department on member estates, are given below :-

Irrigation

North Bank, Assam

In one experiment on irrigation cum pruning (AN 74-Assam kind of tea growing on loamy soil) conducted during 1968, irrigation failed to increase the yield. Unpruned tea whether irrigated or not, gave significantly higher yield over July or December medium skiff. Medium skiffing in July gave considerably larger early crop than even unpruned tea. In another similar experiment (AN 75-Tingamira, Sandy loam soil) there was no significant increase in yield from irrigation in 1968. This may be attributed to good distribution of rainfall during the cold weather 1967/68. In this experiment also, unpruned tea, irrespective of irrigation, gave significantly higher yield than July or December medium skiff. Unpruned tea in both experiments were last pruned in December 1965.

In experiment AN 75, where plots were pruned either in December' 68 or in June' 69 after completing one pruning cycle, there was no gain from irrigation in respect of total yield or early season crop in 1969.

South Bank, Assam

In one experiment on irrigation cum pruning (As 68-Assam kind of tea on heavy soil), the main effect of irrigation was not significant in 1968. However, there was a trend of increased early season crop under irrigation. Unpruned tea produced significantly more yield over July medium skiff, but this difference was not significant when the yield from unpruned was compared with December medium skiffing irrespective of irrigation. The tea was last pruned in December, 1965.

In another irrigation experiment (AS 72- Assam kind of tea growing on silty clay loam), levelling off skiff receiving 5 cm artificial rain per month from December to March produced significantly more crop in 1968 over the rest of the treatments which were deep skiffed and received irrigation at 0 cm, 2.5 cm, 3.8 cm and 5.0 cm per month. There was also a significant increase in early season crop from a levelling off skiff.

Dooars

In one experiment (D. 35-Assam kind of tea, fine sandy loam) a significant increase in total crop from irrigation was observed in 1969 and irrigation also increased early season crop. Medium skiffing in July gave significantly higher crop than medium skiffing in December in unirrigated plots but this significant increase was not observed in irrigated plots. The unpruned tea gave significantly higher crop than tea medium skiffed in December, but failed to give significantly higher crop than tea which was medium skiffed in July.

Nitrogenous Fertilizers

1) **High frequency application of sulphate of ammonia :** Several experiments were in progress to study and compare the effects of single or high frequency applications of different levels of nitrogen on the yield of tea. The levels of nitrogen varied from 100 kg to 250 kg/ha, applied in a single dose, or in 4 to 8 equal monthly doses. Results of some of these experiments are described below :-

South Bank, Assam

In experiment AS 62 (Doolia *jat* growing on loamy soil), there was no significant increase in crop in 1969 from doses higher than 112 kg N/ha and no benefit could be derived from divided doses as compared to single whole applications. The tea was medium skiffed. In experiment AS 64 (Assam kind of tea on loamy soil), application at 100 kg N/ha in single whole dose gave significantly higher yield in 1969 over all the other treatments except 200 kg N/ha applied in a single dose. The tea was deep skiffed. The economics of manuring is shown in Table 1.

Table 1 : Yield of made tea in kg/ha and economics of manuring for the season, 1969.

Treatments	Yield	Cost of fertilizer in rupees	Cost of application at Rs. 12.50 per ha per application	Total cost in rupees	Net financial returns on the basis of marginal return of Re. 0.50, Re. 1.00 & Rs. 2.00 per kg of made tea.		
					Re.0.50	Re. 1.00	Rs. 2.00
T_1 = 100 kg N/ha	4283	259.00	12.50	271.50	1870.50	4011.50	8294.50
T_2 = 150 kg N/ha	3977	388.50	1250	401.00	1587.50	3576.00	7553.00
T_3 = 200 kg N/ha	4206	518.00	12.50	530.50	1572.50	3675.50	7881.50
T_4 = 250 kg N/ha	4071	647.50	12.50	660.00	1375.50	3411.00	7482.00
T_5 = 25 kg × 4 = 100 kg N/ha	4107	259.00	50.00	309.00	1744.50	3798.00	7905.00
T_6 = 30 kg × 5 = 150 kg N/ha	4106	388.50	62.50	451.00	1602.00	3655.00	7761.00
T_7 = 33.33 kg × 6 = 200kg N/ha	4063	518.00	75.00	593.00	1438.50	3470.00	7533.00
T_8 = 31.25 kg × 8 = 250 kg N/ha	4114	647.50	100.00	747.50	1309.50	3366.50	7480.50
L. S. D. (P = .05)	154						
C.V. %	6.7						

In another experiment AS 90 (Manipuri kind of tea growing on heavy soil) where treatments ranged from 100 kg N/ha to 300 kg N/ha in addition to a treatment where 40 kg N/ha was applied as the first dose followed by 40 kg N/ha application for every 400 kg made tea per hectare. In 1969, which was the first year of the experiment, no significant increase in yield was obtained from higher doses than 100 kg N/ha. The tea was unpruned.

North Bank, Assam

In experiment No. AN 59 (Doolia and Khowange *jats*, red bank soil), the results in 1969 when the tea was pruned, were the same as in experiment No. AS 62.

Dooars

In experiment No. D. 33 (Betjan *jat*, sandy loam), there was no significant difference in yield in 1969 between 110 kg N/ha and 220 kg N/ha applied in single dose. No significant gain could be obtained from divided doses at a nitrogen level of 110 kg/ha. However, 220 kg N/ha when applied in eight equal doses gave significantly higher crop than 220 kg N/ha applied in a single dose. It was found that the net financial return on the basis of Re. 0.50, Re. 1.00 and Rs. 2.00 per kg of made tea of eight split applications of 220 kg N/ha was more than 220 kg N/ha applied in single dose but it was less when compared with application of 110 kg N/ha in a single dose. The tea was deep skiffed and had to be skiffed again during the rains following a labour strike.

Cachar

In experiment C. 29 (Chumojan *jat* growing on loamy soil), no benefit could be obtained in 1969 from higher levels of nitrogen than 100 kg/ha or from split doses.

Sulphate of Ammonia Vs. Urea Trials

Two series of single plot trials were carried out in 1969 in mature tea on a large number of estates in Assam, Dooars and Darjeeling. In one series straight sulphate of ammonia was compared with urea at 120 kg N/ha and in the other series, phosphate (P_2O_5) and potash (K_2O) were applied @ 20 kg and 40 kg/ha respectively in addition to 120 kg N/ha in the form of urea and sulphate of ammonia.

There was no significant difference in yield between urea and sulphate of ammonia treated plots in both series of trials.

Sulphate of Ammonia Vs. Calcium Ammonium Nitrate

In experiment No. AS 63 (Dhoedam *jat*, loamy soil) in 1969 sulphate of ammonia, calcium ammonium nitrate (once in three years—first applied in 1966) and NPK mixtures containing sulphate of ammonia, superphosphate and muriate of potash were applied to see whether these are more beneficial than sulphate of ammonia to mature tea in highly acid soils. There was no significant difference in yield between application of calcium ammonium nitrate and sulphate of ammonia i. e., both appeared to be equally good. Application of phosphate and potash, however, failed to produce significant increases over either sulphate of ammonia or calcium ammonium nitrate.

N. P. K. Manuring

South Bank, Assam

In one experiment (AS 34- Doom Dooma and Khorijan *jats*, sandy loam) the effect of using phosphates at two levels i. e., 11.25 and 22.5 kg/ha and potash (K) at 22.5 kg/ha in combination with 112 kg N/ha was studied for eight years (1962-69). In none of the years did the application of phosphate or potash increase the crop significantly. However, in 1969, the P × K interaction was significant.

In experiment No. AS 51 (Betjan, loamy soil) phosphate was applied at 25 kg/ha and potash was applied at two levels i. e., 50 kg and 100 kg/ha in combination with 100 kg N/ha. In 1969, none of the treatments showed significant increase in crop over nitrogen alone but there was a tendency for more yield at both levels of potash.

An experiment (AS 44-Planted in 1955 with Betjan *jat* sandy loam soil) was started in 1964 to study the effect of different doses of phosphate and potash with a constant dose of nitrogen (112 kg/ha) on replanted tea. Potash gave highly significant results in 1969 from annual application at low level (22.5 kg K_2O/ha) as well as from the residual effect of the high dose (224 kg K_2O/ha) which was applied in the first two years of the experiment only i. e., 1965 and 1966. It is interesting to note that when the low level of potash was applied in conjunction with a similar low level of phosphate in the form of single superphosphate, there was no gain over nil application of phosphate and potash. Moreover where potash has been applied, the available potash, content went up and where no potash had been applied, the available potash content was really low.

N. P. K. Manuring of Young Tea

Cachar, Assam

This experiment (C 28- planted in 1964 with Chandkhrika *jat* growing on a bheel soil) was started in 1966 to study the effect of different levels of NPK and their combinations on young tea on bheel soil. There were two levels of nitrogen, phosphorus and potash i. e., nil and 90 kg/ha. The main effects of N. P. K. were not significant in 1969 i. e., treatment combinations failed to produce significantly higher crop over no manure.

An experiment (C. 26- Unknown *jat*, about 60 years old, bheel soil) was started in 1965 to find out the effect of nitrogen or a mixture of nitrogen, phosphate and potash on yield of mature tea on bheel soil. Nitrogen was applied at 100 kg/ha and phosphate and potash were applied at two levels i. e., 25 kg and 50 kg/ha. Nitrogen alone or combinations of nitrogen, phosphate and potash did not produce significantly higher yield over no manure in any year from 1966 to 1969. The lack of response to 100 kg N/ha alone or in combination with two doses

of phosphate and potash may be attributed to the high nitrogen and organic matter contents in the bheel soils of Cachar.

Darjeeling

An experiment (Dj. 23- China *jat*, Coarse sandy loam) was started in 1965 to compare the effects of different combinations of nitrogen, phosphate and potash on the yield of tea. Nitrogen was applied at 65 kg/ha and phosphate and potash were applied at two levels i. e., 22 and 45 kg/ha. In 1967 and 1968, all plots receiving fertilizers gave significantly more crop over no fertilizer. The main effect of nitrogen was highly significant but phosphate and potash failed to show any beneficial effect in terms of crop outturn.

Effects of High Doses of Potash on Yield

A number of single plot trials, where high doses of potash ranging from 90 kg/ha to 360 kg/ha were applied in addition to the normal dose of nitrogen in an attempt to induce mangesium deficiency, were carried out in a large number of estates during 1967 and 1968 in Assam and the Dooars. In none of the trials was magnesium deficiency induced but it was most interesting to find that in the majority of trials there was good response to potash. In one estate the increase in crop was 31% with 180 kg K_2O/ha. and 78.6% with 360 kg K_2O/ha. In others, the increase varied from 3% to 22%.

The results indicate that it will be worthwhile for estates to try out trials with different levels of potash at say the rates of 180 kg and 360 kg K_2O/ha

Liming

In experiment No. AS 78 (Betjan *jat* on loamy soil) both one and two tonnes of slaked lime per hectare gave significantly higher crop in 1969 over no lime in presence of 100 kg N/ha as sulphate of ammonia. But no significant difference in yield was observed between the levels of slaked lime when nitrogen was applied at the rate of 200 kg/ha as sulphate of ammonia. The data are shown in Table 2.

Table 2 : Yield of made tea in kg/ha

	Nitrogen in kg/ha	
Slaked lime	N_{100}	N_{200}
No slaked lime	835	1057
Slaked lime 1 tonne/ha	1078	1113
Slaked lime 2 tonnes/ha	1036	1091
L. S. D.(P = .05)	91	
(P = .01)	125	
(P = .001)	163	
C. V.%	8.1	

Soil analysis of the experimental plots indicated that irrespective of the nitrogen levels lime dressings reduced significantly the soil acidity in both top and sub-soil layers. The reduction of soil acidity had been found to be progressive with increasing levels of lime dressings.

In experiment AS 77 (Betjan *jat*, sandy loam soil), liming failed to produce any significant effect on the yield of tea in 1969, in presence of either 100 kg N/ha or 200 kg N/ha. A similar result was obtained in experiment No. AS 79 (Assam kind of tea on heavy soil).

North Bank

In experiment No. AN 80 (Tingamira *jat*, sandy loam soil) exactly similar results to those of Experiment Nos. AS 77 and AS 79 were obtained during 1969.

Soil Rehabilitation

North Bank, Assam

In experiment No. AN 46 (claycy loam soil), where the tea was replanted in spring 1966, previous sub-soiling and deep ploughing cause highly significant increase in crop in 1969 over no sub-soiling

and no deep ploughing. It was observed that the effect of green cropping for two years was significantly better than no green crop or green crop for one year only.

Dooars

In one experiment D. 28 (loamy sand soil) the results obtained in 1969 from previous sub-soiling and deep ploughing were the same as the North Bank experiment. Two years rehabilitation under green crop was significantly better than one year and one year was significantly better than no rehabilitation.

Soil climatological survey

A few experiments were started in 1962 to study the growth of different kinds of tea under widely varying soil and climatic conditions and also their response to different levels of nitrogen.

Five clones i. e., TV. 1, TV. 2, TV. 3, TV. 18 and 3/22 were used combined with nitrogen levels at N_0, N_{55}, N_{110} and N_{165} kg/ha. Results of one experiment in 1969 are given in Table 3.

Dooars

In experiment No. D. 24 (heavy soil), the main effects of nitrogen and clones and the interaction between clones and nitrogen levels were found to be significant as in the previous year.

Clones TV. 18 continued to give a significantly higher yield than the rest of the clones. As in 1968 clones TV. 1 and 3/22 TV. 1 was significantly better than 3/22 and there was no significant difference between TV. 2 and TV. 3 (Table 3)

Table 3 : Clone × Nitrogen interaction : Yield of made tea in kg/ha

Nitrogen	Clones	TV.1	TV.2	TV.3	TV.18	3/22	Means for N
No.		1109	655	600	1236	927	905
N_{55}		1546	964	1073	1946	1345	1375
N_{110}		1709	945	1218	2582	1382	1567
N_{165}		2018	1436	1255	2982	1818	1902
Means for clones		1596	1000	1036	2186	1368	

L. S. D.	(P = .05)	between individual figures	= 280
,,	(P = .01)	,, ,, ,,	= 376
,,	(P = .001)	,, ,, ,,	= 498
	C. V.%		11.6
L. S. D.	(P = .05)	between clone means	= 140
,,	(P = .01)	,, ,, ,,	= 188
,,	(P = .001)	,, ,, ,,	= 249
	C. V. %		11.6
L. S. D.	(P = .05)	between nitrogen means	= 154
,,	(P = .01)	,, ,, ,,	= 233
,,	(P = .001)	,, ,, ,,	= 375
	C. V. %		= 2.4

The overall response to nitrogen was linear and this was true for all clones except TV. 2 where there was no difference between 55 kg N/ha and 110 kg N/ha. Clone TV 18 at 165 kg N/ha gave significantly higher crop than at 110 kg N/ha.

Weedicides

A few short term experiments were conducted during the year with different weedicides and some of the observations are given below :-

1) Afalon at 4 kg per hectare as pre-emergence application gave good control of broad leaved weeds and some shallow rooted grasses for about $2\frac{1}{2}$ months in youngish mature tea areas.

2) A blanket spray of Tafapon at 3.5 kg/ha mixed with 2,4-D at 0.75 kg (a.i)/ha can be used to control a mixed population of broad leaved weeds and thatch type of grasses. Repeat spraying as,when, and where necessary with Gramoxone only at 1:200. The mixture should not be used in tea below three years of age.

3) Better control of weeds has been obtained by mixing weedicides with a spreader (eg. Teepol, SNID PGN etc.) or a sticker (eg. Tenac etc.) at 1 :500 with the spray fluid on a sunny and coudy day respectively.

With Gramoxone, 'Tenac' or 'Teepol' should not be used. However, a non-ionic spreader like SNID-PGN can be used at the same dilution as mentioned above.

RESEARCH AND EXPERIMENTAL

Introduction

The Department suffered a setback by the sudden death of Dr. K. N. Sharma, Senior Agriculturist on the 11th April, 1969. Mr. S. C. Barua, Agriculturist, retired on the 5th July, 1969 and Dr. F. Rahman took over charge of the department on the 5th August. Dr. R. N. Roy, was appointed as Second Agronomist, from the 1st of March, 1970. In the circumstances it was not possible to incorporate this department's report in the 1968-69 Annual Report; thus this report will cover the whole period 1968-70.

The range of subjects under study and experimentation in this department covers the rehabilitation of land, planting and spacing, manuring, pruning, plucking, seasonal dormancy in tea and root studies in the root laboratory.

Rehabilitation of Land

An experiment on rehabilitation of uprooted tea areas (B. 6.3) started in 1962, showed definitely increased yields as a result of green cropping. Subsoiling and deep ploughing before green cropping did not show any beneficial effect. The results are presented in Tables 1 and 2.

Another experiment (B 11/3) was started in 1966, to study the effects of different species of grasses and green manure crops on soil rehabilitation. Final results will not be available for some more years because the last planting has not been completed yet. The two experiments initiated at Hunwal (S_1 & S_2) were discontinued because of the failure of the rehabilitation crops.

Table 1 : Pruning weight in kg per hectare-1968

Green Crop / Cultivation	No Green Crop	One year under Green Crop	Two years under Green Crop
No Subsoiling and No Deep ploughing	1217	2114	2492
Subsoiling and Deep ploughing	1355	1918	2055
L. S. D. (P = 0.05) = 656kg/ha			
C. V.% = 23.4			

Table 2 : Yield of made tea in kg per hectare-1969

Green Crop / Cultivation	No Green Crop	One year under Green Crop	Two years under Green Crop
No Subsoiling and No Deep ploughing	496	653	729
Subsoiling and Deep ploughing	487	636	551
L. S. D. (P=0.05) = 167 kg/ha			
C. V. % = 18.7			

Table 3 : Yield of made tea in kg per hectare

Treatments		Years										
		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Mean
Spacing	120 × 120 cm	398	985	818	1138	1270	1214	1076	938	1070	1233	1014
	150 × 98 cm	461	1052	912	1252	1454	1396	1232	1074	1147	1313	1129
	150 × 75 cm	449	991	808	1139	1323	1240	1123	950	1089	1237	1035
	150 × 60 cm	600	1144	914	1218	1413	1350	1204	1052	1175	1364	1143
	120 × 60 cm	634	1256	979	1316	1483	1390	1258	1062	1197	1344	1192
	L. S. D. at P = 0.05	91	134	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	—
	C. V. %	4.7	3.3	4.7	5.1	5.3	5.3	6.2	6.3	5.9	4.7	—
Nitrogen	90 kg/ha	516	1043	878	1199	1378	1297	1206	1028	1127	1320	1099
	135 kg/ha	505	1091	891	1220	1397	1341	1164	1025	1165	1334	1113
	180 kg/ha	505	1123	889	1219	1391	1315	1166	994	1115	1241	1096
	L. S. D. at P = 0·05	N. S.	51	N.S.	N. S.	N. S	N. S.	N. S.	N. S.	N. S.	61	-
	C. V. %	13.4	10.6	8.1	7·9	9.3	8.8	10.2	11.0	10.3	10.6	
Jat	Betjan	566	1143	910	1263	1418	1314	1162	964	1103	1259	1102
	Stock 203	451	1028	863	1162	1360	1322	1195	1066	1168	1338	1095
	L. S. D. at P. = 0·05	35	54	25	48	N. S.	N. S.	N. S.	59	N. S.	53	-
	C. V. %	5.9	4.2	2.4	4.3	4.2	4.8	5.3	5.0	5.6	3.5	

Planting and Spacing

The results of an experiment (B 104) are described below. There were 5 spacings *viz.*, 120 × 120 cm, 150 × 98 cm, 150 × 75 cm, 150 × 60 cm and 120 × 60 cm; 3 levels of nitrogen, *viz.*, 90, 135, and 180 kg/ha; and two *jats*, *viz.*, Betjan and Stock 203. The main effects are recorded in Table 3.

It can be seen that differences between spacing treatments have not reached the level of significance after 1961 when the tea was four years old in the field. This tea was planted in October, 1957 and as such it is safe to conclude that differences in spacing affect yield in earlier years and gradually the differences become less and less.

It can also be seen that there is no response to nitrogen beyond 90 kg/ha.

It is interesting to see that in the early years Betjan outyielded stock 203 but in later years the order has been reversed.

The *jat* × nitrogen interaction was only significant in 1961, 62 and 63 and during those three years there were significant increases in yield due to the higher doses of nitrogen in the case of Betjan, whereas there was no such increase in the case of Stock 203.

A new experiment (B 8/2) was planted out with *jat* tea in 1966 and yields according to plant population are given in Table 4.

Talle 4 : Yield of made tea in kg per hectare according to plant populations

Spacing	120×120 cm	120×90 cm	120×90 cm	120×75 cm	120×60 cm	120×75 cm	L. S. D. P=0.05	C. V. %
No. of bushes/ha	6944	9259	18518	11111	13888	13675		
Yield 1968	62	82	86	76	108	98	26	20.1
Yield 1969	234	292	329	276	340	368	79	17.0

* two plants in each hole

It is evident that there has been no significant increase in yield as a result of planting two plants in one hole. It can also be seen that except for 120×75 cm spacing, there is a direct relationship between yield and bush population. The low yield in the 120 × 75 cm spacing plots was due to poor growth of the tea bushes in bad patches.

Manuring

A number of experiments have been conducted on different aspects of manuring and the results are briefly summarised below :

Forms : Experiments on forms of fertilizer have been conducted with nitrogenous fertilizers only The results of one experiment (B 102.1) conducted over a period of three years indicate that urea, ammonium sulphate-nitrate, ammonium sulphate and calcium ammonium nitrate are equally good. It was peculiar to observe a trend of decline in the yield of plots receiving sulphate of ammonia and an improvement in the yield of plots receiving calcium ammonium nitrate. Although no explanation can be offered for this peculiar trend it is believed, that this is unlikely to be a treatment effect. In another experiment (B 64.1), conducted over a period of four years, annual applications of ammonium sulphate and calcium ammonium nitrate were compared with application of calcium ammonium nitrate after one or two years of ammonium sulphate application. There was no significant difference between treatments although the continuous use of calcium ammonium nitrate appeared to depress yields. From these experiments it can be concluded that ammonium sulphate, urea and ammonium sulphate nitrate are equally good. The evidence in favour of calcium ammonium nitrate is not conclusive but using calcium ammonium nitrate in alternate years will be quite safe.

Levels and frequency of Nitrogen

An experiment (B 111/2) was started in 1966 using Clone 3/77 planted in1959. Nitrogen doses were 112, 157, 202 and 247 kg/ha and these doses were applied singly in whole doses in March and in split doses of 4, 5, 6 or 8 times per year at monthly interval during March to October. The treatment differences in this experiment did not reach the level of significance in any of the four years. Under the conditions of the experiment application of nitrogen above 112 kg/ha, whether split or not, did not result in increased crop.

Another experiment (B 113.1) was started in 1965. The treatments consisted of 90 kg nitrogen and 135 kg nitrogen per hectare applied in whole doses in March and in split doses of 2, 3, 4 times per year at two month interval during March to October. The treatment differences were not significant in any of the years from 1965 to 1969. The results of the combined analysis for the five years are presented in Table 5.

Table 5 : Mean yield of made tea in kg per hectare (1965-69) *affected by dose and frequency of Nitrogen application.*

Treatments	Yield
Nitrogen at 90 kg/ha in one application	1660
Nitrogen at 90 kg/ha in two applications (45 × 2)	1682
Nitrogen at 90 kg/ha in four applications (22.5 × 4)	1655
Nitrogen at 135 kg/ha in one application	1701
Nitrogen at 135 kg/ha in two applications (67.5 × 2)	1715
Nitrogen at 135 kg/ha in three applications (45 × 3)	1751
Nitrogen at 135 kg/ha in four applications (33.5 × 4)	1742
L. S. D. at P = 0.05	N. S.
C. V. %	2.5

It can be seen that neither the higher doses of nitrogen nor the split applications have brought about any significant increase in the yield of made tea.

Phosphate Manuring

Most experiments on mature tea at Borbhetta have not shown any benefit from phosphate manuring. One experiment has shown a beneficial effect (B 7) while another (B 5.1) has conversely shown a positively deleterious effect. It is thought that lack of response to phosphate may be related to the form of fertilizer used, *viz.*, super-phosphate. With this in view a new trial has been initiated using different forms of phosphate.

Potash Manuring

The results in respect of potash manuring are presented in Tables 6, 7 and 8. It must be remembered that the treatments have been applied consistently for a long time.

Expt. B 5.1

(Seedling tea planted 1962)

Table 6 : Yield of made tea in kg per hectare

Treatments	With Shade		Without Shade	
	1968	1969	1968	1969
No Potash	837	869	948	906
22.5 kg Potash/ha	1032	1044	1078	1024
L. S. D. at P = 0.05	82	80	48	54
C. V%	17·3	16·7	9·4	11·2

Expt. B 7

(Old seedling tea planted 1935)

Table 7 : Yield of made tea in kg per hectare

Treatments	1968	1969
No Potash	880	1098
22 kg Potash/ha	940	1206
67 kg Potash/ha	1012	1285
L. S. D. at P = 0.05	73	78
C. V %	19.2	16.1

Expt. B 105

(Clonal tea planted 1953)

Table 8: Yield of made tea in kg per hectare

Treatments	1968	1969
No Potash	1212	1404
45 kg Potash/ha	1350	1597
90 kg Potash/ha	1452	1731
180 kg Potash/ha	1618	1912
L. S. D. at P = 0.05	144	164
C. V. %	14.3	13.9

These experiments have consistently shown responses to potash. It is significant to note that even an application as high as 180 kg K_2O/ha per year since 1962 is giving increases in yield over the application of 90 kg K_2O per hectare. The results of B 5.1 and B 105 also show that in the initial years, the response to potash at low doses may be nil or very small but application at higher doses in the beginning (B 105) will give response if the soil is deficient in potash. In B 105 there was no significant increase in yield caused by applying 45 kg K_2O per hectare until six years had passed but the application of 90 and 180 kg K_2O per hectare gave significant responses after two years of application (yield data for the first two years were not recorded).

The removal of potash in the plucked shoots will not entirely explain the response to high doses in the early years because made tea has, on an average, 2.5 per cent potash content. Potash cannot be considered to be fixed in the soil and become permanently unavailable. It is in dynamic equilibrium with the exchangeable potassium and the fixed potassium is released as soon as the pool of exchangeable potassium gets depleted. It, thus, appears probable, that before potassium can become available for the production of increased yield *per se*, it must first satisfy the requirement of the frame of the tea bushes.

Manuring in relation to Shade

Yield from an experiment (B 43) where N. P. K. 2 :1 :1 mixture has been applied at various rates since 1930 to unshaded tea, are shown in Figure 1.

General view of an Experiment in Borbhetta.

Shade was planted in 4 replications in 1959 and these became well shaded from 1962 onwards. Introduction of shade increased yields substantially as can be seen in Figure 2.

Another experiment (B 5.1) on *jat* tea planted in 1962 has shown that response to nitrogen is more in unshaded tea whereas potash response is more under shaded tea.

Method of Manuring

An experiment (B 43 C. 1) on placement of phosphatic fertilizers was conducted for three years during 1967-69. The treatments consisted of no phosphate and 20 kg phosphate in the form of single superphosphate broadcast or placed at 10, 20 and 30 cm deep. There were no significant differences between the control and the placement treatments, and also between the placement treatments themselves in any of the three years.

Another experiment (B 15.2) on forking urea compared to broadcast application did not show any advantage of forking.

Pruning

In one experiment (B 106/4) a prune - prune-deep skiff- medium skiff cycle was compared to a prune-unprune unprune-unprune cycle. Both cycles were repeated with and without irrigation. Irrigation did not have a significant effect either on the total crop or early crop in any of the years. Unpruned tea, yielded more than pruned, deep skiffed and medium skiffed tea. It is interesting to note that maximum crop was obtained in the second unpruned year after which there was a decline. The treatment yields were partitioned and it was found that the increased yield from unpruned tea came from the early crop. In the same experiment pruning, deep skiffing and medium skiffing in July resulted in more early crop than the unpruned tea, but the total crop during the year was reduced by 45 percent in the year of prune, by 37 percent in the year of deep skiff and by 20 percent in the year of medium skiff.

Plucking

In one experiment (B 19/1) on Clone 106/1 where only two and a bud was plucked on 2, 3, 4, 5, 6, 7 and 8 day rounds and compared with standard plucking on a 7 day round it was found that plucking two and a bud only on a seven day round compared with standard plucking reduced the crop from 1155 kg/ha to 697 kg made tea/ha.

In yet another experiment (B 23/1) where different plucking systems were compared, plucking pruned tea at 18 cm to the janam gave significantly

the highest crop. It also indicated that there may be crop loss if no breaking back was done even on a 7 day round. Plucking on a 5 or 6 day round, appeared to give less crop in pruned tea compared to plucking on a seven day round.

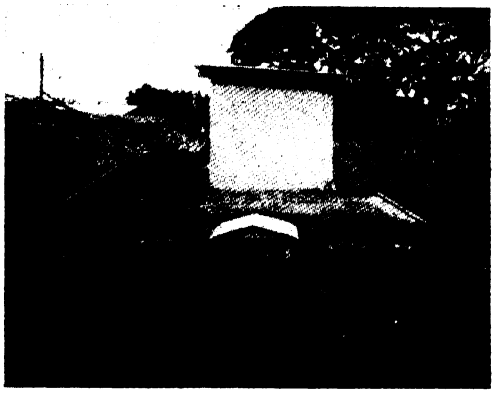
Seasonal Dormancy in Tea

An experiment (B 103) was done in collaboration with the Botany Department to try and confirm the effect of light on the winter dormancy of tea. This was in continuation of the first experiment reported on page 61 of the 1968-69 Annual Report of the Botany Department. In general there was a suggestion of increased crop when the bushes were exposed to extra hours of light in continuation of the day length either in the evening or early hours of the morning. Illumination at other hours of the night appeared to have little effect. It was however, apparent that winter dormancy could not be completely broken by a longer day length.

It was interesting to observe that the tea bushes started flushing three weeks after spraying gibberellic acid while the untreated bushes as well as bushes subjected to varying light treatments were dormant. The bushes treated with gibberellic acid flushed while the others were dormant and this alternation of flushing could be noticed upto May 1970.

Root Laboratoy

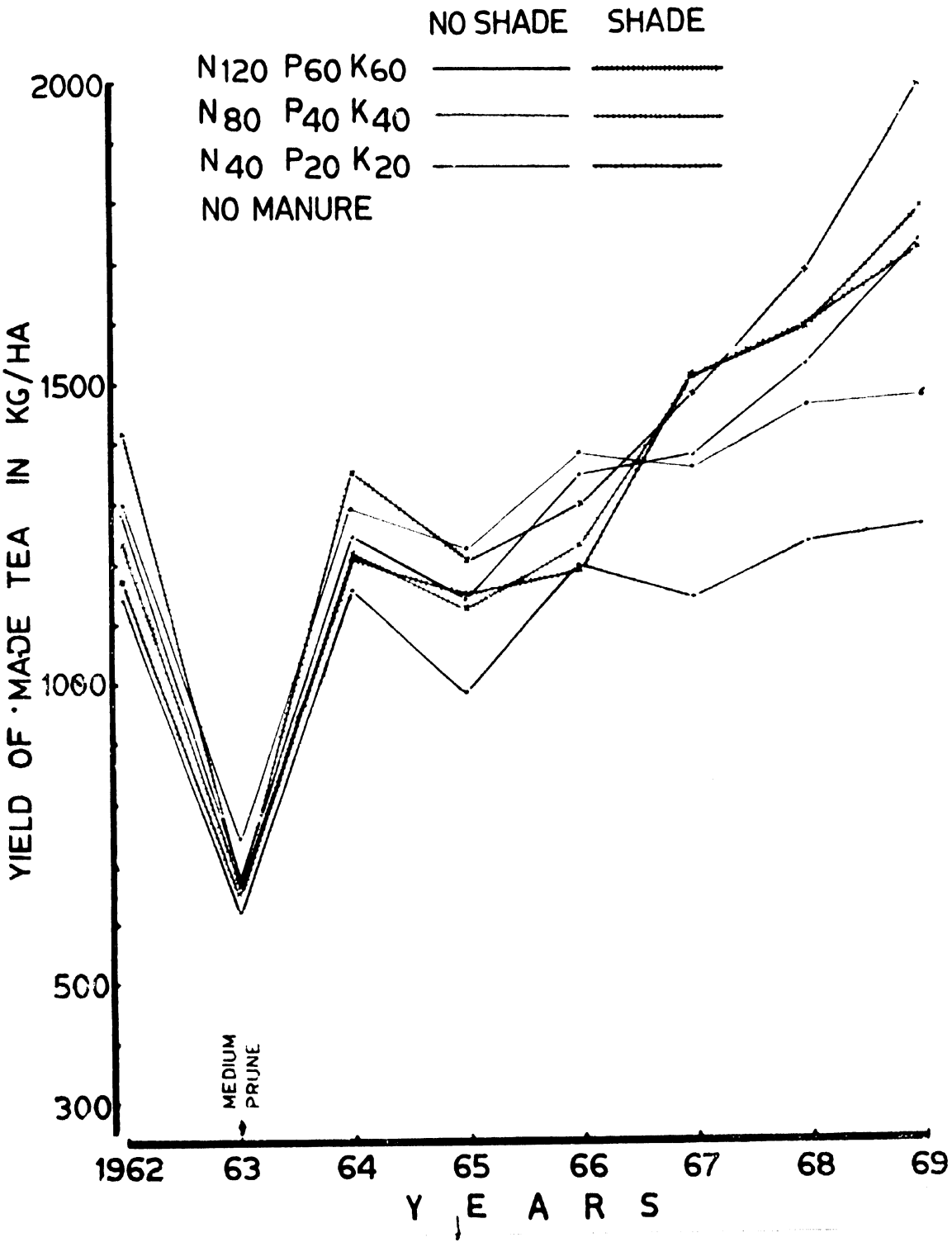
An underground root laboratory was constructed in 1968. The laboratory is essentially a concrete tunnel with the roof at ground level. It has got 10 glass windows in the wall which rest against the soil. Pusa Giant Hybrid Napier and Guatemala grass *Mimosa invisa* and *Crotalaria anagyroides* were planted and their root system was observed in 1969 season. One year old plants of Clone 106/1, 19/29/13 and Tingamira seedlings were planted in May 1968. A second lot of Clones 106/1 and 19/29/13 was planted in April 1969 and their root systems appeared in all the windows in February 1970. It was interesting to note that the root development of 106/1 was the most prolific but those of 19/29/13 and Tingamira were much poorer. There was not much difference in the growth of above ground parts of either clones or *jat*.



Outside View of the Underground Root Laboratory. Tea can be seen growing on the left and grasses on the right of the roof of the root laboratory. The ventilator can be seen in the foreground and the main building with the entrance in the background.

A study of the root system of grasses and legumes indicated that the roots of all these species died when they were inundated by the rising water table during the rains, but during the dry season, root growth quickly spread downwards again.

Inside View of the Underground Root Laboratory. On either side of the corridor are glass windows through which roots of tea and grasses can be seen and studied.



Corrigendum

The legend under Fig. 1 will go under Fig. 2 and the legend under Fig. 2 will come under Fig. 1, and read "Fig. 1" as "Fig. 2" and "Fig. 2" as "Fig. 1"

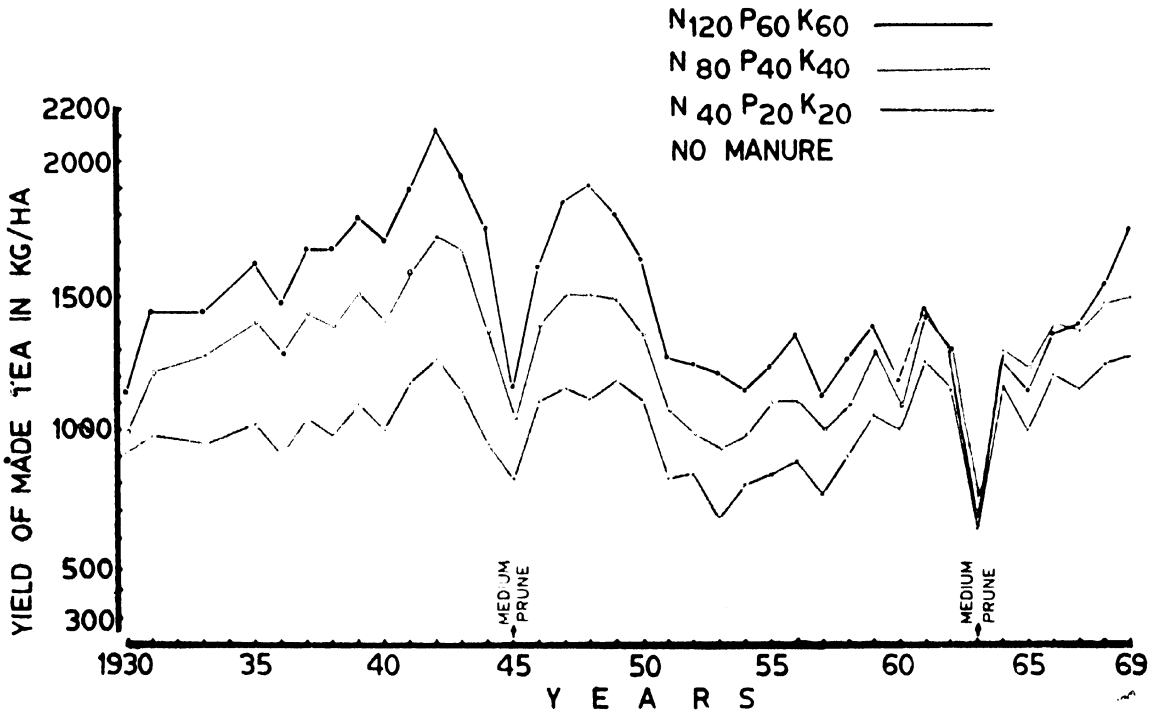


Fig 2 – Yield responses of shaded and unshaded tea to different N.P.K. combinations in comparison with no manure (1962-69).

Further studies on tea and grass roots are continuing.

BORBHETTA FIELD EXPERIMENTAL ESTATE REPORT

Labour—The average daily attendance of labourers during the current year, compared with the last four years, is as follows :-

Year		No. of labourers engaged
1965	...	250.22
1966	...	247.57
1967	...	230.66
1968	...	220.00
1969	...	208.63

Crop—The total yield of green leaf during the current year, compared with the last four years, is as follows :-

Year		Yield
1965	...	1,32,131 kg
1966	...	1,34,730 kg
1967	...	1,29,455 kg
1968	...	1,29,021 kg
1969	...	1,44,985 kg

Of the 1969 crop 1,34,241 kg green leaf was sold to the Haroocharai Tea Co., Ltd., and the remainder was used for experimental purpose. General plucking was stopped on 30. 11. 69.

Vegetative Propagation—The following supplies were made to member estates/outstations from Borbhetta.

Supplies made	1968—69	1969—70
Pretreated/fresh cuttings	2,18,540	3,16,825
Scions	Nil	600
Clonal plants	900	500
Rooted cuttings of shade trees	42	18

Soils and Meteorology Department

Soil Fertility Survey as a basis for Fertiliser use

The Soil Fertility Survey of all the fourteen tea districts has been completed, and the district results have been published in Tocklai Occasional Scientific Papers Nos. 1 to 9. On the basis of the survey data, and the results of associated soil investigations derived from relevent field trials, a final report has also been prepared. The main conclusions drawn in this report are as follows :

The Survey suggests that within a tea district, soils vary appreciably in texture and two to three different classes of soils can occur within a district, but extreme types like sand, silt or clay rarely occur.

Irrespective of the region or textural class, substantial losses of aggregates take place in the early twenty years of cropping, which are either partially or fully recovered by a regeneration process effective between medium age and old tea of forty years or more.

All nutrients, as well as organic matter deplete very rapidly in the early twenty years of cropping and, thereafter, the rate of decline slows down ultimately leading to a state of almost equilibrium.

The survey data show that irrespective of regional differences, nitrogen and organic matter contents of the top 30 cm (1 ft.) soil layers are linearly correlated, and the entire loss of nitrogen over a forty year cropping takes place from the organic matter source.

The nitrogen supplying capacity of an average tea soil, down to 90 cm depth, has been calculated to be 90 kg/ha at one per cent rate of mineralisation which bears a good agreement with the average response of tea towards applied fertiliser nitrogen under field conditions, (recorded from trials carried out all over the North East India tea areas).

The additional nitrogen requirement due to the depletion of organic matter has been found to be 4 kg/ha/annum from the survey data, and 5 kg/ha/annum from a field trial laid out at Borbhetta. In the light of this information, it is tentatively suggested that an increase of 12 kg/ha nitrogen every third year, along with replacement manuring (that is removed in crop over two years) of phosphate and potash in the same year is worth trying out.

The regional trends of the losses of phosphate and organic matter have been found to be similar. Also, it has been found that considerable loss of the organic phosphate fraction of the soils takes place due to age of cropping, whereas the inorganic phosphate fraction does not undergo substantial decrease over the same period. The depletion of soil organic phosphate is due to the net mineralisation loss over the entire cropping period, and the inappreciable loss of inorganic phosphate is due to the immobilisation of this form of phosphorous under acid soil conditions.

Average C:N:P ratio of tea soils has been found to be 107:10:0.9, which is close to the established ratio of 100:10:1 for general mineral soil's.

The phosphate supplying capacity of an average tea soil (0-30 cm) has been found to be 11 kg/ha/year, calculated at the rate of one per cent mineralisation per year. The calculated amount bears a good agreement with the estimated removal of 10 kg/ha/year phosphate (P_2O_5) by an average crop of 1,000 kg year made tea. Replacement manuring of phosphate in mature tea at the rate of 20 kg/ha once in three years (recently recommended by Tocklai) thus gains additional support from the net mineralisation loss of soil organic phosphate content. Besides, maintenance of a good litter of dead leaves, prunings and shade tree droppings is necessary for conservation, and even improvement of the organic phosphate reserves in soils. Trial laid out at Borbhetta shows that mulch itself can contribute substantial quantities of phosphorus to the available pool through a slow mineralisation process.

Results of a pilot trial show that mature tea needs more phosphate than can normally found in an acid soil, and provided the phosphate fixing capacity of

the soils is earlier satisfied by repeated dressings of soluble phosphate fertilisers, then the demand for phosphate by mature tea can be met by fresh addition of soluble inorganic phosphate fertilisers. It therefore appears that phosphate fixation is a semi-permanent property of tea soils, and can be modified by good management methods namely, (a) continued addition of small doses of soluble inorganic phosphate fertilisers, and (b) the regular addition of pruning litters, shade tree droppings and dead leaves with an aim to build up a mulch layer which will serve as a source of phosphate reserve and which besides, will encourage surface rooting.

The survey results show that the average estimated loss of available calcium, magnesium and potassium from a 90 cm profile over 40 years is equivalent to the theoretical addition of approximately 12,000 kg/ha sulphate of ammonia, which is roughly in actual practice the amount used in forty years.

Exchangeable (available) potassium comprises only about 0.4 per cent of the total potassium content as has been shown by the survey results. Loss of exchangeable potassium over 40 year cropping period suggests that much has been lost from the non-exchangeable (reserve) source too, over the same period of cropping.

The size of the available (exchangeable) potash in Dooars and Terai, and the sizes of the reserve (non-exchangeable) potash in Assam soils, strongly suggests that application of potassic fertilisers to mature tea may produce beneficial effects.

On the basis of the survey data, a suggestion has been made recently for the application of large dressing of potassic fertilisers (200-300 kg/ha K_2O) to 4 ha (10 acres) of very old tea in each estate in addition to 200 kg/ha nitrogen, or, alternatively, the usual rate of nitrogen as basal dressing. The idea behind the application of such a large dressing is to reach an equilibrium value of exchangeable (available) potash in a short period of time. By the equilibrium value of available potash, is meant that level above which any excess application will be wasteful. However, to maintain the established equilibrium value of available potash an annual dressing of potash equivalent to the amount lost in crop should always be given. Actual estate results obtained until the time of writing this report, show distinct gains from application of large quantities of potash to old debilitated tea as described above.

Soil analyses of some recent Advisory Department field trials demonstrate that the response of nitrogen to mature tea can be greatly increased when the soil available potassium level has been partially corrected through repeated applications of even low to moderate doses of potash (22.5-100 kg/ha K_2O applied annually) An increase of 1 kg/ha soil available potassium has resulted in an increase of 2 to 3 kg/ha extra made tea in these experiments, laid out on sandy loam soils around Jorhat. It has been calculated that for an increase of 1 kg/ha soil available potash, roughly 10 kg/ha K_2O as muriate of potash needs to be applied.

Soil analyses of the field trials referred to above, show that the availability of potash gets impaired due to the cumulative build up of calcium (contained in the superphosphate) in soils, when both muriate of potash and superphosphate are applied together in soils having "low" available (exchangeable) potash contents.

Leaf analysis from a long term N. P. K. trial also confirms the inhibitory effect of calcium contained in the superphosphate on the uptake of potassium, thereby, strongly suggesting that a proper balance between potassium and calcium is essential for ensuring efficient uptake of potassium by tea. The role of secondary nutrients should also receive consideration while choosing a phosphorus-carrier for tea; it is tentatively suggested that mono or di-ammonium phosphate or triple superphosphate (with minimum calcium contents) should be tried out as alternative phosphorus carrier.

Potassium uptake in those plots where a significant crop depression has been noted, is governed by a Ca : K ratio of 1:2. On the contrary, potassium uptake in those plots, where significant crop increase has been noted, is governed by a Ca : K ratio of 1:4. It is tentatively suggested that the ratio of $K/\sqrt{Ca}$ is likely to reflect the state of available potassium for tea at a given time.

The removal of prunings has been found to hasten the process of depletion of soil potassium reserve. A pilot trial carried out at Borbhetta showed that by stopping the removal of prunings alone for three successive years, the exchangeable (available) potash content of the top 30 cm soils can be increased by about 60 kg/ha; for an increase of an equivalent amount of soil available potash using fertiliser, one needs to apply roughly 600 kg/ha muriate of potash worth about Rs. 312/-. The value of pruning litters for conservation, and even improvement of the soil potassium reserve, will therefore be readily understood.

Soil rehabilitation; Seasonal variations of Soil aggregates

Top soils to 15 cm (6 in.) layers were collected from the soil rehabilitation experiment laid out at Borbheta at monthly intervals from March to December, 1969. These soils were analysed for water stable aggregates of various sizes in order to find out any seasonal influence on the aggregate status of rehabilitated and non-rehabilitated soils. For this purpose, plots were choosen in a way so as to include those which were previously under either different rehabilitation crops for a period of three years or under the canopy of old tea. Soil sampling for investigation of seasonal effects actually started after uprooting of the various rehabilitation crops or the tea, and only when replantation was completed.

The percentages of the total soil aggregates at different times of sampling are shown in Table 1.

Table 1 : Percentage total soil aggregates (expressed on a dry weight basis) of rehabilitated and non-rehabilitated soils after replanting of tea at different times of the year.

Tea/or rehabilitation crops	Before uprooting of the rehabilitation crops or tea December, 1968 (mean p. c. total aggregates on dry weight basis)	After uprooting of the rehabilitation crops or tea, and replantation in 1969 (mean p. c. total aggregates on dry weight basis).									
		Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
I. **Non-rehabilitated soil** Canopy of old tea (A)	65	65	65	65	45	35	50	50	40	35	65
II. **Rehabilitated soil**											
Memosa invisa (B)	80	80	75	80	65	80	75	75	75	70	70
Guatemala Grass (C)	80	75	65	75	75	80	75	80	80	75	75
Thatch (D)	75	75	70	70	60	65	70	75	60	70	70
Guatemala plus Mimosa (E	80	80	70	70	70	60	80	65	65	70	70

The following conclusions can be drawn from the above table :

Non-rehabilitated soils are more influenced by the season than their rehabilitated counterparts. Non-rehabilitated soils show appreciable decrease in the total soil aggregates during June/July, but this decrease is gradually made up with the approach of the cold weather and by December the soils regain fully, showing thereby that the effect of season is only of transient nature. Rehabilitated soils, on the other hand, show only minor fluctuations due to season.

However, a distinct but small reduction of total soil aggregates takes place after one year's exposure.

It is suggested that two samplings in a year, once in June/July and again in December/January, should suffice for providing adequate information on the effects of different rehabilitation measures or other management methods upon the soil aggregate status.

To counteract the probable loss of soil aggregates (though it may be transient in nature) in the rehabilitated fields due to climate, it is suggested that the soil surface should be covered with at least a thin layer (10-15 cm, i. e., 15t/ha fresh organic matter) of mulch in December/January untill the replanted tea fully covers the ground.

Seasonal Fluctuations of pH, Total Nitrogen, Available Potash, Available Phosphate and Organic Matter Contents in a Sandy Loam Soil Under Tea.

An exercise was carried out to follow the seasonal changes of acidity, nitrogen, potash, and phosphate contents in the top 15 cm (6 in.) layers of soils utilising Borbhetta Field Experiments Nos. B. 34 1/7 and B. 106/4. The organic matter changes were followed in the top 0-15 cm and 15-30 cm layers of soils.

Experiment B. 34. 1/7, started in 1965, includes three treatments. These are, prunings not removed, prunings removed, and prunings removed but mulch from outside added at the rate of seven tonnes dry organic matter per hectare. Two treatments of the experiment B. 106/4 are unpruned tea for the past three years, and tea on a three years pruning cycle of pruning-deep skiffling-medium skiffling. Soils were collected, in the last year of the three-year cycle, at bimonthly intervals between April 1969 to February 1970 and were analysed for the different chemical components mentioned earlier.

It has been found that (i) a progressive but slow increase of soil acidity takes place from autumn to the premonsoon period (i.e., October to June), which is followed by a well marked decline during the main cropping season (i. e., June to October); ((ii)) soil nitrogen, irrespective of the treatments, increases during the fall (i. e., December to April). During the early cropping period (i. e., April to June) soil nitrogen decreases significantly, and , thereafter, from June to December soil nitrogen remains stationery, (iii) available phosphate and potash contents, irrespective of the treatments, increases appreciably during spring (i. e., February to April) which is followed by a significant decrease during the early cropping period (i. e., April to June). Between June to February available phosphate does not change. Available potash, however, declines again in October but this temporary decrease after the main crop, is soon recovered to the June level and no further change takes place untill February.

From the seasonal trends mentioned above, it is suggested that for N, P and K estimations, sampling soils twice at six monthly intervals, i. e., once in spring (March/April) and again in the autumn (September/October) should suffice to derive precise information on the effects of the different management methods like manuring, mulching etc. upon the available nutrient status of soils.

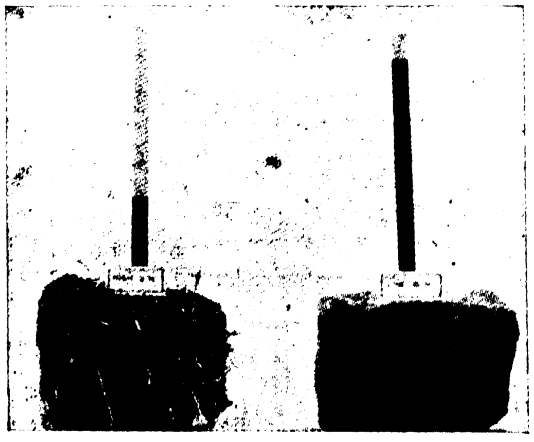
The seasonal trends of pH, N, P and K can be explained by the fact that freshly added organic matter mineralises fast during the cold weather (December to April). As a result, (i the liberated nitrates make the soil slightly more acidic; (ii) the release of mineral nitrogen and phosphorus from the organic source substantially enriches the available pools of these nutrients; (iii) the potash residues added by the decomposition of organic matter contribute substantially to the available pool of soil potash.

However, the contributions made towards the available pools of N, P and K get rapidly exhausted during the early cropping period. From June to December the soil nutrients (with the exception of potash) remain practically constant probably due to luxury consumption by tea during the early cropping period. Since potassium is heavily withdrawn by the growing crop, another significant valley of depression is noted in October at the end of the main cropping season, but due to the presence of a dynamic equilibrium between available and reserve potash in our tea soils, replenishment of the available pool to the June level soon takes place.

Seasonal fluctuations of the soil organic matter content were also examined by collecting soil samples

at monthly intervals down to 30 cm depth (successive 15 cm layers sampled separately) for one complete year from April, 1969 to March, 1970, and estimating organic carbon in these soils. The over-all picture shows that the soil organic matter is not appreciably affected by seasonal influences, but a distinct peak is observed in March/April period irrespective of different management methods. This peak either represents a maximum increase of soil organic matter due to organic matter addition in November, or conversely it represents the maximum depletion of soil organic matter due to the removal of prunings in November. Thus soil sampling during March/April should afford us precise information on the contributions of organic amendments towards soil organic matter.

It seems that a minimum time lag of four months is necessary for evaluation of the benefits from added organic matter, during which period the freshly added organic matter is expected to have its full effect in soils. It is confirmed that the effects of the different management methods on the soil organic matter status reported last year (Annual Scientific Report 1968/69, p. 43) are precise estimates of the maximum contribution or loss of soil organic matter, since soils were collected during March/April when the different treatments should have their full effects.



Influence of Organic Matter Addition on Soil Porosity

The importance of organic matter content in regeneration of soil aggregates has been well recognised in our past studies. This regeneration process may consequently influence the porosity of soils. An exercise was carried out during the dry period of 1969/70, i. e., between October '69 to April 70, to find out the changes in soil porosity as a result of keeping or removing pruning litter from plots, and of mulching. Borbhetta field experiment No. B. 34.1/7 was utilized for this purpose. This experiment has been described earlier in this report.

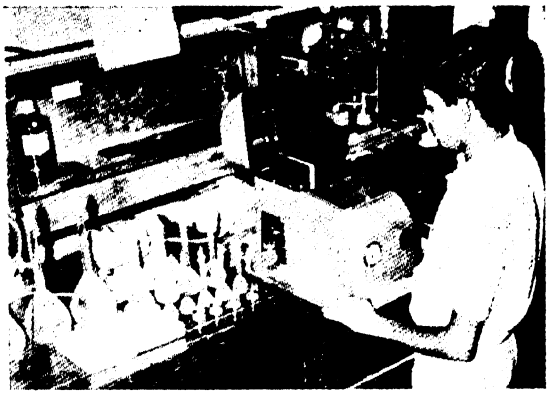
Undisturbed core samples (six cores from each replicate plot) were collected at bi-monthly intervals between October, 1969 to April, 1970 and their densities determined.

From the mean data of 36 cores (6 replicates $\times$6 cores) under each treatment, it has been found that (i) regular addition of pruning litters for a period of three years has significantly improved the porosity of the top 0-15 cm soil layers, compared to the plots from where pruning litters have been removed regularly for three years (ii) The beneficial effect of prunings on soil porosity has been maintained all through the dry season (iii) addition of mulch from outside at the rate of seven tonnes dry organic matter per hectare, in lieu of pruning litters, has produced relatively lower benefit on the soil porosity compared to the plots receiving prunings.

Agricultural Meteorology

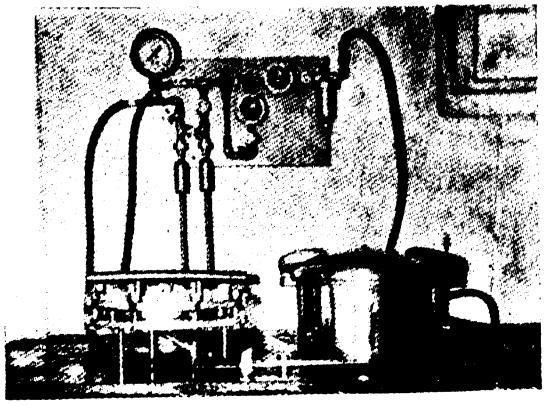
Evaporation : Computation of potential evaporation rates, Eo, by the Penman analysis of meteorological data, as well as direct measurement of evaporation using U. S. class A open pan continued. Ten day data have been used for a comparison of measured (class A pan) and calculated (Penman) evaporation over a period of five years, and regression equations have been worked out for the four different meteorological sites. The goodness of fit was tested at all the sites and found to be satistically significant ($P \leq 0.001$), $r^2 = 0.92$ for Tocklai, 0.86 for Silcoorie, 0.75 for Nagrakata and 0.61 for Nagri Farm. The equations relating these comparisons are :

For Tocklai, $Y = 4.2616 + 1.3849\ x$, where
Y = the calculated value (Penman),
and X = actual measurement (U. S. class A pan)

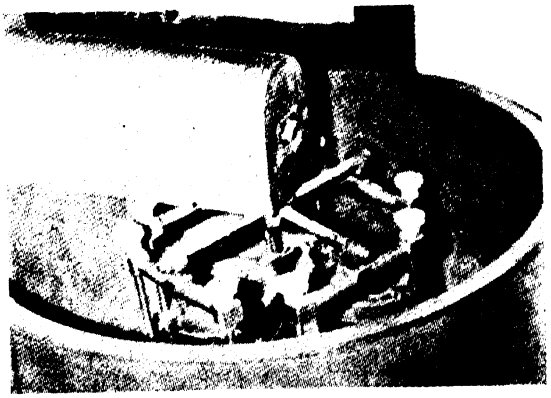


Determination of available Potassium present in soils (by flame photometric method)

Estimation of Soil nitrogen by micro distillation apparatus.



Pressure membrane
apparatus for determination
of soil moisture



Determination of Soil Aggregate.

For Silcoorie, $Y = 3.7191 + 1.2351\ X$
For Nagrakata, $Y = 6.2521 + 0.8815\ X$
For Nagri Farm, $Y = 10.5624 + 0.9544\ X$

There is, therefore, a good prospect of estimating evaporation according to Penman's method under estate condition using the inexpensive class A pans, instead of recording expensive basic meteorological data like solar radiation, temperature, wind speed and humidity necessary for Penman's calculations *per se* Penman's calculated values will be used for the final estimation of water requirements by tea under estate conditions.

Summary of Meteorological Data : Meteorological conditions in ten-day units have been given for 1969 for all the meteorological sites, and a summary of the observations for 1969 is given in the Appendix.

Rainfall Measurement : The object of rainfall measurement by placement of gauges at different heights, and the first four month's results were reported last year (Annual Scientific Report 1968-69, p. 47). Data collected over the whole year confirms that the ground level gauge caught more rain every month than either the standard gauge placed at a height of 30 cm or the gauge placed at 60 cm height. The gauge placed at 120 cm height recorded more rain than the ground level gauge particularly during the monsoon months, whereas the gauge at 180 cm height showed almost equal catch as that of ground level gauge throughout the year. The reason for the unexpected behaviour of the gauges at 120 cm and 180 cm heights is not known, but rainfall measurements will continue for one more year to ascertain the reproducibility of these trends. Meanwhile it can safely be concluded that a ground level gauge will provide us precise estimate of rainfall, and for hydrological studies this is preferable to the standard I. M. D. gauges (i. e., at 3.0 cm).

Rainfall analyses : Rainfall analyses have been carried out utilising standard raingauge data recorded at Bhogotpore T. E. (Dooars), and at Silcoorie T. E. (Cachar) from 1931 to 1960 in order to find out monthly distribution of rainfall according to the categories of daily rain. The analyses have been carried out by grouping every five years data into eight different categories of daily rain, as has been reported last year for the Tocklai long-term rainfall data (Annual Scientific Report, 1968/69, p. 48).

Research and Advisory Analyses

About 21,000 soil analyses have been made during the year. The break-up is as follows :

(i) **Research :** For Soil Department's projects, as well as for the other departments, 8,300 estimations have been carried out.

(ii) **Advisory :** For tea estates alone, 12,700 estimations have been carried out.

The demand for soil analyses by estates continued to be more than the last year. Further, frequent requests for detailed soil analyses of problem area soils have been complied with as far as practicable.

PLANT IMPROVEMENT

Release of Biclonal Seed Stocks

The programme for improvement of the growing stock in North East India and the progress made till date were briefly reviewed in the Annual Report for 1967-68, pp. 50-52. On the basis of the trials conducted in different geographical regions of N. E. India, the first improved biclonal seed stock bred at Tocklai was released for the Darjeeling district during 1967 and two more biclonal stocks, Nos. 449 and 450, are selected for release during 1970 for the plains districts.

Stock 449 is a cross between the popular clone TV 1 (19/29/13) and another dark leaf clone of above average vigour and quality. The stock is fairly uniform in its growth habit, size and appearance of leaf. Trials conducted at different regions indicate it to be superior both in yield and quality to the best available commercial *jats*. The stock appears to be drought tolerant to the same extent as TV 1 and may be found suitable for drought prone areas of Assam, Cachar, Dooars and Terai.

Stock 450 is a cross between the high quality Assam clone TV 2 (20/23/1) and a vigorous hybrid clone of the Southern (Cambod.) form. The stock combines characteristic Assam quality with vigour of the Southern type. Yield of this stock has been found to be far superior to the best known commercial *jats*. The stock is hardy and likely to do well in dry areas.

A few more promising biclonal stocks are still under trial.

Cytological Investigations

Detailed cytological investigations on some triploids, tetraploids and aneuploids discovered recently were carried out with a view to utilise these plants in future breeding schemes. Karyotype analysis and meiotic behaviour indicate amphiploid origin of most of the polyploids and aneuploids investigated.

Tea chromosomes
Diploid plant with 30 chromosomes

Tea chromosomes.
Tetraploid plant with 60 chromosomes

Parallel studies were also undertaken in a number of related species and genera to investigate the possible presence of non-tea genome in cultivated tea, evidence for which was obtained in morphological, anatomical and chemical investigations. Preliminary observations reveal that morphology of the chromosomes of most of the related species and also a few genera are more or less similar to those of tea. On the basis of these investigations a few interspecific-hybridizations were undertaken to verify the possibility of their intercrossing with tea.

Induction of Mutation

Seeds of two biclonal and one commercial varieties were treated with 1 in 100, 1 in 250 and 1 in 500 parts solutions of ethyl methyl sulphonate for different lengths of time. No visible symptom of occurrence of any mutant was observed in the seedlings. These seedlings will be planted in the field for further observation on growth, yield and quality.

Selection of Vegetative Clones

A large number of bushes from different commercial *jats*, biclonal and polyclonal progenies were screened during the year for the selection of elite vegetative clones. Examination of manufacturing results and yield records led to the selection of 33 bushes for rooting and long term trials.

Another lot of 73 clones are under different stages of long term trial.

Clonal Criteria

As proposed in the Ann. Rep. for 1968-69, p. 52, more than 50,000 observations were made this year, the purpose of which was explained in the Ann. Rep. for 1967-68, pp. 53-54.

The observation reported in Ann. Rep. for 1967-68, pp. 54-55 that the taster's assessment of the value of a cup of tea is influenced by the value and proportion of each of the shoot components (e. g. bud, first leaf, stem etc.) led us to examine the nature of variation of shoot components between clones. It was observed that the proportions of 'soft' and 'hard' tissues in 2 + bud shoots can vary significantly between clones. An example is given in Table 1.

Table 1 : Proportion of soft and hard tissues in 2 + bud shoots of different clones

	Clone 106/1		Clone 19 17/15	
	Fresh wt. (g)	Percent of shoot wt.	Fresh wt.(g)	Percent of shoot wt.
Soft tissue (bud, first leaf and stem between bud and second leaf)	0.2241	41.22	0.2492	47.25
Hard tissue (Second leaf and stem below it)	0.3196	58.78	0.2782	52.75
Total	0 5437		0.5274	

Interaction of clone and soft and hard tissues is significant at 0.1 per cent probability level (P at 0.05: 0.0369 g)

The possibility of utilising this information in the selection of vegetative clones is being investigated.

PLANT PHYSIOLOGY

Drought and Waterlogging

Improvement of drainage systems has recently become an important part of N. E. Indian tea cultivation but no quantitative data on the effects of poor drainage on the productivity of the tea bush is available. The well known loss of yield attributable to waterlogging can be due in part to secondary factors such as root diseases but the direct effects of excess soil moisture have not previously been studied. An experiment to determine these effects was carried out using the uptake of carbon dioxide as a measure of the plant's activity. From a population of healthy six month old seedlings, three matched groups of six plants were chosen. Group A was waterlogged by placing plants up to the rim of the earthenware plant-pots in water, Group B remained unwatered (drought series) while the control Group C was watered daily. Individual attached leaves of each group of plants were placed in leaf chambers under a constant light and temperature regime in growth cabinets and carbon dioxide (CO_2) uptake measured by infra red gas analyser. This was repeated on many occasions using different leaves from each plant in each group. It was interesting to note that no visible effects were noted on the waterlogged plants even after 10-14 days while drought symptoms were obvious 2-3 days after watering ceased. In spite of the lack of visual symptoms, the rate of CO_2 uptake of both the waterlogged and droughted series was greatly reduced as shown in Table 2.

Table 2: Rate of CO_2 uptake, parts per million per cm^2 per minute

	ppm CO_2
Normal Plants	21—43
Waterlogged Plants	0 5
Droughted Plants	1—6

Some plants of Group B were watered when wilt symptoms become very severely marked and after 4-5 days the rate of CO_2 uptake was almost identical to that of the control plants of Group C. In the case of the waterlogged plants of Group A, some of which were allowed to drain until the soil moisture equalled that of the controls, recovery was not complete after 14 days when the experiment was terminated.

Respiration rates of leaves in the dark were also measured for each group and were found to be almost identical in the droughted and waterlogged groups but lower than the controls. Totalling up the rate of CO_2 uptake over a period of 12 hours of daylight and the respiratory loss over a period of 24 hours (assuming that light respiration is equal to dark respiration), there is a net loss of carbon dioxide over a 24 hour period in the waterlogged plants and this can only be the result of using reserve carbohydrates as respiratory substrates. In such young plants reserves are usually low and it is doubtful if they would have survived in the field for a long period under similar waterlogged conditions. It is of interest that the extremes of drought and waterlogging produce identical results although the reasons are obviously very different.

It is frequently found in estate practice that drains are laid out the year following planting, the main reason given being that the land has had time to "settle down", another being the ease of bringing the seedlings (or clonal plants) by tractor directly to where they are being planted which would not be possible if the area had drains. The questionable validity of both reasons must be balanced against the debilitating effect of prolonged waterlogging demonstrated by these experiments.

It is also possible that in very heavy soils the use of two year old seedlings or clonal plants would be advisable as these will normally have a higher root/shoot ratio and have greater carbohydrate reserves to withstand a prolonged period of a high soil water regime.

In the case of the droughted plants the rate of carbon dioxide uptake was reduced before any signs of wilting were seen, especially in plants which were not actively flushing and even after watering it was five days before they fully recovered from the temporary shortage. If irrigation facilities are available then its more rational use would be to keep the soil at or near to field capacity than the general practice of allowing soil to reach temporary wilting point before re-irrigating.

Photosynthesis Studies

(a) Continuing the work on photosynthesis reported in the Ann. Rep. 1968-69, p. 53, the light saturation point of mature leaves was determined and found to be between 0.2 - 0.3 g cals/cm^2 min^{-1} (at a carbon dioxide concentration of 360 ppm at 15 C) for leaves which had been subjected to high light regime previously (Fig. 1).

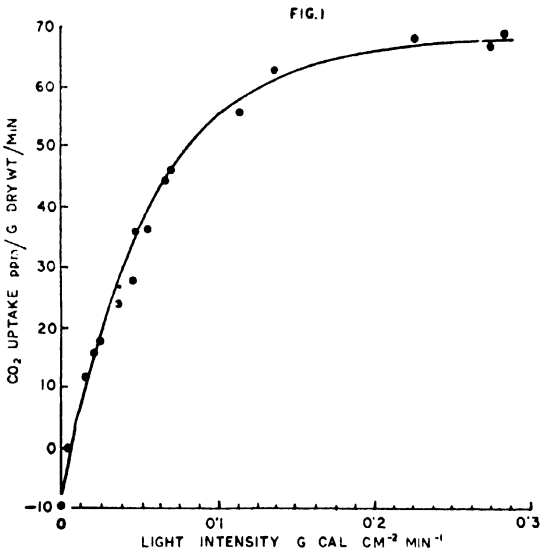
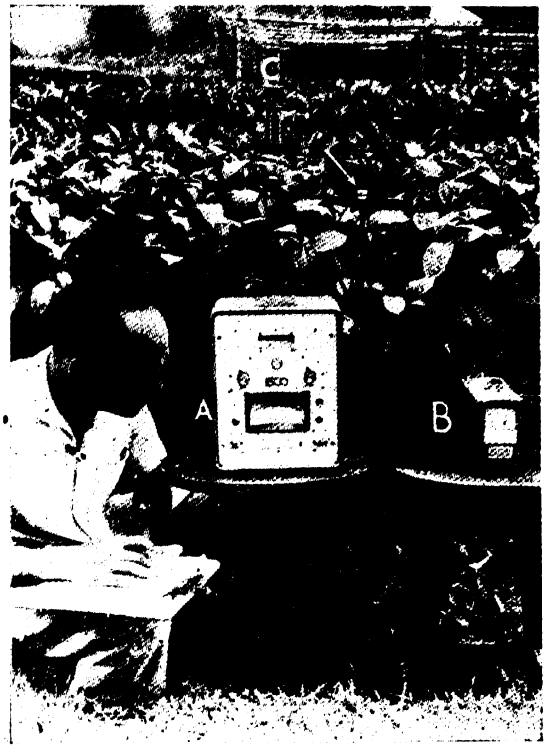


Fig. 1. Rate of photosynthesis expressed as parts per million carbon dioxide taken up per gram dry weight of mature leaves per minute at different light intensities. The light energy received by a square centimetre of leaf surface in a minute is expressed in gram calories.

For heavily shaded leaves the saturation point was below 0.2 g cals. It was observed that above 0.4 - 0.5 g cals there was a reduction in the rate of net photosynthesis which was not associated with

high leaf temperatures or stomatal closure. It may be that the high level of assimilates in the leaves of small plants results in the "sink" (roots) becoming incapable of removing these products at a rate rapid enough to allow maximum photosynthesis to continue. In view of the importance of this finding the experiments will be repeated with plants which have large root/shoot ratios.



Measurement of solar radiation, leaf temperature and relative humidity in a tea field. The position of the sensitive head of the probe receiving solar radiation is marked with an arrow. The probe is connected to the automatic recorder A which measures the intensity of solar radiation at different wavelengths of the visible spectrum. Instrument B is recording leaf temperature. C is measuring relative humidity.

(b) Leaves between 12-16 months old were found to have an efficiency of between 40%-60% of 6 month old leaves in terms of dry matter production.

(c) An unexpected finding was the high photosynthetic activity of young green stems which on a dry weight basis almost equalled that of old leaves at low light intensity.

Respiration Studies

The effects of high leaf temperature on net photosynthesis on tea leaves have been reported previously (Ann. Rep. 1968-69) and in view of the high ambient air and soil temperatures found in N. E. India, compared to those of most other tea growing areas, the effects of such temperatures on plant respiration were determined. Samples of leaves, young green stems, older brown stems, one year old stems, tap root and fine feeding roots were used and the procedure was as follows. The plant material was placed in a leaf chamber in the dark and the chamber surrounded with a water jacket which was thermostatically controlled. Air of known composition and at the same temperature as the water bath, was passed over the sample and the increase in carbon dioxide due to respiration was measured on an infra red gas analyser. Mechanical damage to living tissue causes an increase in respiration rate and great care was taken to see that this effect was reduced to a minimum. When a steady state of respiration was reached the temperature of the system was slowly raised and again allowed to reach a steady state at a higher level of temperature. This was repeated over a range of 20°C to 40°C which covers most of the conditions likely to be met with in the field, except for leaves which may reach even higher temperatures in unshaded sunny conditions. Results are shown in Fig. 2 and are based on the total carbon dioxide evolved in parts per million per minute per gram dry weight of tissue. The high respiratory activity of leaves and fine roots is clearly seen but in a mature bush these represent only a small proportion of the total dry weight of the plant. Respiration increases with increase of temperature. Hence the respiratory losses involved during the hottest months of the year in N. E. India will be considerably higher when compared with those from cooler countries like Kenya or most of Ceylon where ambient temperature are much lower.

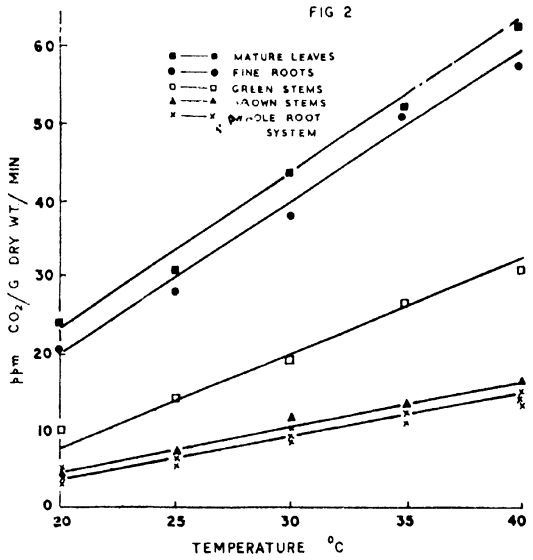


Fig. 2. Rate of respiration expressed as parts per million carbon dioxide evolved by a gram dry weight of tissue per minute at different temperatures. Carbon dioxide output by roots, stem, leaf etc. is shown separately.

In terms of net productivity of the tea bush the total respiratory loss during the period May to October in the plains of N. E. India is estimated to be double that of bushes in Kenya and mid and high elevation Ceylon and may explain the wide differences in starch reserves observed.

Seasonal Dormancy

It was reported in the Ann. Rep. for 1968-69, pp. 61-62 that increasing winter day length to 13 hours by providing weak artificial illumination before dawn and after dusk increased the crop harvested from unpruned bushes during November to March and hastened bud-break and subsequent growth of pruned bushes. The illuminated plots produced 60 per cent more crop during the year than the unilluminated controls. Winter dormancy was broken also by injecting gibberellic acid (GA) into dormant plants.

In collaboration with the Agriculture Department, another experiment was conducted in 1969-70 in which the long, winter night was interrupted by one and two hours of weak, artificial illumination given at different times viz. from 4 to 6 p. m., 6 to 8 p. m., 8 to 9 p. m., 9 to 10 p. m., 10 to 11 p. m., 11 to 12 p.m , 12 to 1 a. m., 1 to 2 a. m., 2 to 3 a. m., 3 to 4 a. m., and 4 to 6 a. m. I.S. T. Illumination for hours from dusk to dawn and spraying of gibberellic acid at fortnightly intervals were two additional treatment of the same experiment. The treatments were commenced in October 1969 and continued till the third week of March 1970. Gibberellic acid was sprayed at the rate of 10 parts per million until mid January, after which the concentration was raised

Induction of winter growth by gibberellic acid (GA) treatment. Plants marked A were injected with GA on 30th December, the arrow showing the position of the dormant terminal bud on that day. Plants marked B were controls. Photograph taken on 21st February.

to 100 ppm. Each bush received 45 ml of spray fluid at every spraying round and there were 44 bushes in each treatment. The experiment was carried out on a 11 year old section of tea planted with clone 19/29/13. The tea was not pruned but plucking continued throughout the cold weather of 1969/70.

All treated plots showed increase in crop harvested during the six month period from November to April, the increase varying from 55 per cent to 4 per cent. The GA treatment recorded the maximum

increase of 55 per cent over the untreated control, and increase of more than 40 per cent was obtained in three illumination treatments.

Illumination enhanced yield without altering the normal timings of the phases of growth and dormancy, while GA treatment changed the times of flushing. Bushes treated with GA were flushing at the end of January when all other bushes were lying dormant; when other bushes were flushing, the GA treated bushes were conversely relatively dormant.

The yields of the experimental plots will be recorded throughout the year. Meanwhile, efforts are being made to assess the feasibility of using GA treatments under commercial conditions.

Shade × nutrient × clone trial

This experiment was started at Tocklai in 1958-59 to study the effect of mechanical shade and tree shade in the presence and absence of inorganic fertilisers on a wide array of 25 clones covering almost the entire range of tea cultivated in the plains of N. E. India. A short description of the experiment appeared in the Ann. Rep. for 1962, pp. 26-28 and brief progress reports in subsequent years (Ann. Rep. 1964, pp. 37-38; Ann. Rep. 1965, p. 41; Ann. Rep. 1966, p. 38; and Ann. Rep. 1968-69, p. 58). The experiment was terminated in 1967-68 and the area has since been used for other observations. The large mass of data collected in the course of the years is being prepared for publication; meanwhile a few results of general interest are given here.

The description given in the Ann. Rep. for 1962. pp. 26-28 will show that the bushes were planted close, at a spacing of 45 cm × 60 cm, but were spaced out to 90 cm × 60 cm in early 1964 by removing alternate rows at the ground level. Frame height of bushes had been kept low which in 1970, after 12 years, was only 50 cm from the ground.

Table 3 shows the yields of manured plots in sun and under mechanical bamboo screens and shade trees, both allowing 50 to 60 per cent of the incident light to reach the tea bushes underneath.

Table 3 : Fresh weight of plucked shoots per bush in grams. Average of 25 clones

Year	Manurial treatment kg/ha	Full sun	Screen	Tree
1961	Nil	108	144	170
1962	N 112	172	183	268
1963	N 112	210	212	303
1964	N 112	226	269	379
1965	N 112 P 90 K 90	293	323	412
1966	N 112 P 90 K 90 Mg 22	383	341	444
1967	-do- + Zn 11, B 5.5 Mn 5.5, Mb 5.5 as foliar spray	494	476	579

Maximum crop was harvested every year from the plots under shade trees. Yield under the bamboo screen was higher than in full sun until 1965, when P and K were applied to the plots for the first time. P and K application was repeated also in 1966 and 1967. Application of P and K improved the yield of plots in full sun which out-yielded the screen plots from 1966 onwards.

In addition to N P and K, all three plots were manured with magnesium (Mg) in 1966 and the bushes were sprayed with solutions of zinc (Zn), boron (B) manganese (Mn) and molybdenum (Mb) in 1967 at concentrations shown in the table. The large yield increase observed during 1967 suggests that besides N P K and Mg tea bushes looking apparently healthy may benefit from a supply of one or more of these micro-nutrients both in sun and under shade.

Plucking Round

Mature bushes grown without shade were plucked at intervals of 1, 4, 7, 10 and 14 days. Only 2 + bud and single banjhies were plucked on 1 and 4-day rounds. The 7-day round without breaking back, which contained occasional 3 + bud and double banjhies, was taken as the standard and shoots plucked on 10 and 14 day rounds were broken back above the third leaf, the broken back portions being weighed separately to determine the gross weight of harvests. Single and double banjhies also were weighed in with the 2 + bud fractions of the 10 and 14 day rounds.

Table 4 shows the weight of 2 + bud fractions together with the gross weight of harvests from 10 and 14 day rounds.

Table 4 : Grams fresh weight of shoots harvested per bush in plucking rounds of different lengths

Length of plucking round	No. of times plucked	Clone 3/19	
		Weight of 2 + buds	Gross weight of harvests*
1 day	218	1486	1486
4 day	55	1705	1705
7 days	32	1620	1620
10 days	22	1554	2106
14 days	16	979	1480

* 2+ buds and the broken back portions

The weight of 2 + bud shoots harvested in the course of a year was not affected by the length of plucking rounds at least upto 10 days, but a decline was perceptible in the 14 day round. While the gross weight of pluckings from 10 and 14 day rounds was 35 to 50 per cent higher than the weight of the respective 2 + buds, it is of interest to note that the gross weight of harvests in 10 day rounds was higher than in the 14 day rounds.

A more comprchensive experiment is planned for 1970.

Order of Lateral and Tea Quality

In an experiment conducted by the Tyroon Tea Company Ltd., mature bushes were thrown out of plucking in July and a new plucking table established 10 cm above the old level about two weeks after the let up. Shoots plucked from the newly established plucking table and from areas where the plucking level was not raised were manufactured and the teas tasted at Tocklai under code. A distinct improvement in the liquor characters of teas from the let up area was observed some six weeks after the commencement of tipping at the new level and the improvement persisted for three-four weeks after which the level of quality dropped but still remained at a level somewhat higher than that of the control area.

It seems the first and to some extent the second order laterals arising from a primary shoot are capable of producing teas of improved liquor characters at any time of the year compared with teas produced by the higher orders and tippings.

We are grateful to the Tyroon Tea Co. Ltd. for allowing us to associate in these observations.

Periodicity of Root Growth in Tea

Indication of a periodicity in the growth of tea roots was obtained in an earlier observation on plucked bushes (Ann. Rep. 1960, p. 51). This was confirmed by growing young tea plants in specially designed root observation boxes with glass windows. Six periods of root growth and five periods of top growth were observed in a year, the growth periods of the roots tending to alternate with that of the top.

Re-examination of the old data on plucked bushes also revealed periodic growth of the roots, but these growth periods were ahead of the unprunned bushes by about a month. Pruning advanced shoot growth also by about a month, demonstrating the interdependence of top and root growth.

These results support our recommendations that cultural operations like transplanting, pruning and centering should not be done at the time of vigorous top growth when root growth is at a minimum.

General

The fundamental work carried out during the last few years on light, daylength, photosynthesis and respiration are now beginning to produce a firm foundation on which to forecast the likely response of the tea bush to a particular set of environment and cultural conditions. The completion of the controlled environment growth room and isotope laboratory is expected to help fill in the remaining gaps in our knowledge to complete the picture of carbohydrate economy of a whole tea bush under diverse conditions.

Entomology Department

TEA MITES

Effects of shade and manure : The population dynamics of the mite complex of tea, comprising of Red spider (*Oligonychus coffeae* (Nietner), Scarlet mite (*Brevipalpus phoenicis* (Geijskes), Pink mite (*Acaphylla theae* (Watt) Keifer) and Purple mite (*Calacarus carinatus* (Green) were studied for four consecutive years on 20 year old bushes. In the first year the whole area was well shaded with *Albizzia odoratissima* and had low mite incidence. At the end of the first year shade trees were felled in some sections and fertilizer applications were made both according to experimental design. In the subsequent three years population dynamics of the mites were studied under the following conditions of shade and manuring.

- 112 kg N/hectare with and without shade.
- 224 kg N/hectare with and without shade.
- 224 kg N, 45 kg P and 90 kg K/hectare, with and without shade.

Throughout the study period, the bushes were plucked regularly and have had the usual agricultural operations including biennial spraying of Tedion V-18 and Trithion 20 E. C., each at 1.25 litres/hectare.

Apart from a slight decrease in Red spider populations in the NPK treated plots, manurial treatments had practically no effects on the population growth of the mites. Irrespective of the manurial treatments, shaded tea always had less mites than unshaded tea, though mite densities in the former never went below the critical level of 2 to 3 mites/sq. cm of the leaf surface.

Inspite of the exposure to different combinations of shade and manuring, the seasonal cycles of the four species were well synchronized with each other. They increased rapidly from March and population peaks were reached during June to July. From September onwards their number declined but not below the critical levels.

After the shade trees were felled, i. e. in the first year of experimental treatment, Pink mites were most numerous, but towards the end of the second year Red spiders were dominant. In the third year of treatments both Red spider and Purple mite populations were stabilized, but Scarlet mites declined. Since the four species damage leaves in identical manners by sucking, competitive displacement between them was a possibility, but the evidence was not conclusive.

General Incidence of Mites

Scarlet mite : In the Dooars dark leaf *jats* were highly prone to Scarlet mite but the light leaf *jats* were less prone : in Darjeeling China *jats* suffered more than the light leaf and dark leaf *jats*. Throughout the year, skiffed teas in the Dooars, Darjeeling and Assam had more mites than in the pruned teas. Both young (5 year) and mature (15 year) bushes were equally susceptible to Scarlet mite, but in poorly drained areas the mite incidence was generally higher than in well drained areas.

Tocklai clones TV_1 and TV_7 were highly susceptible to Scarlet mite but the rest of the Tocklai release clones were not so susceptible.

Red spider : There was no significant difference in the incidence of Red spider on skiffed teas in the northern and southern slopes of Cachar tillas. But pruned and untouched teas on the northern slopes suffered more than those on the southern slopes. This set of findings appear to be irreconcilable and the problem needs a good deal more study.

TEA APHID

Life system of *Toxoptera aurantii* Boyer Population peaks were reached on 15 year old bushes at Tocklai in February and October both in 1967 and in 1968, but the February peak was not noticed in

1969 because there has been an overall decline in the numbers of aphids and their predators over the last three years.

The alate or winged forms were predominant during November to March, but during the rest of the year, de-alate or wingless aphids were common. Although the wingless forms were quite capable of moving between the bushes, new infestations resulted almost invariably from the dispersal of the winged aphids during November to March. In course of the migration, nearly 70% alates were lost, but once the colonies were set up the loss was compensated by the high rate of multiplication of the surviving alates. When the aphid numbers in colonies exceeded 50, alates appeared but they did not migrate until the following winter.

Both winged and wingless aphids suffered mortalities caused by predators and parasites : 16 species of insect predators and two parasites have been identified (Annual Report 1966, 1968). Some predators were active during initial colonization and again when the aphid numbers rose to peaks. They were partly responsible for the population decline during April to September, but were unable to curb the progressive development of new infestations. This happened because most of the natural enemies had a fairly wide range of host preferences and did not feed exclusively and selectively on aphids.

Migration of the winged forms between tea bushes and from alternate hosts outside tea was the crucial factor in spreading infestations. Insecticidal treatments checked the inter-bush migration, but were unable to prevent movements from outside the tea areas.

LOOPER CATERPILLAR

Mortality Factors During the Development of *Biston suppressaria* Guen

By using life-table techniques mortality factors were identified. The looper moths laid about 800 eggs each on the trunks and branches of shade trees up to a height of 8 metres. Within ten days the eggs hatched and first instar larvae emerged. Egg mortality was rare and hairy cushions protected the eggs from predation. Newly hatched larvae descended to the tea by suspending themselves on silken threads. They could not secrete more than three metres of thread : consequently those in the upper branches were unable to reach the tea below. Besides, a gentle breeze during the downward movement carried many larvae away from the bushes. Lopping the branches at 3 metres above tea could induce the moths to lay eggs higher up and this in effect could prevent the majority of the larvae from descending on tea.

Looper moth resting on the trunk of a shade tree. Note the camouflage effect.

The first and second instar larvae were predated on tea bushes by hemipterous sucking insects. The third and fourth instars were not predated, but were parasitised by hymenopterous and dipterous insects. Fungal infection of the pupal cases also interfered with the moth emergence. These external mortality forces were operating in addition to natural mortality during moulting.

The total absence of the natural enemies of the fully developed caterpillars in the field could be a contributory factor in looper out-breaks in some years : some chemicals are known to adversely affect

the predator-parasite complex of looper. However, the recurring three year looper cycle in some areas suggest that by themselves natural enemies might not be the only population regulatory force. The search for other factors will therefore be continued.

EFFECTS OF AGRICULTURAL CHEMICALS ON VARIOUS PESTS

Weedicides : A preliminary survey showed that in termite infested areas weed control with Grammoxone slightly increased the activities of the live wood eating termites (*Microcerotermes* spp.). The effect was particularly marked on spots where the vegetable debris was heaped, because dried leaves, stems and branches attracted these termites. However, if this increase had any significant effect on the overall termite population was not immediately clear.

Grammoxone treatment had no effect on the incidence of Red spiders on tea bushes once the weeds below were killed.

Fungicides : 25 year old tea bushes were sprayed with Blitox (Copper oxychloride) and Nickel chloride each at 0.50 kg in 200 litres of water at ten day intervals during November to February. Blitox treatment slightly increased the numbers of Red spiders and Scarlet mites but its effects on Pink and Purple mites were not at all clear. Nickel chloride had no clear-cut effect on mite numbers.

Insecticides : Tea seed bearers were sprayed at fortnightly intervals from mid-October to end-December with Ekatin 25 E. C. (0.125%), Rogor 40 E. C. (0.13%), Ethion 47 E. C. (0.094%), Endrin 20 E. C. (0.02%) and Thiodan 35 E. C. (0.07%) to find out if the spraying of these chemicals in their immediate vicinity or on themselves would affect seed formation. Preliminary data showed that barring Ekatin 25 E.C. none of the chemicals affected pollination and the subsequent seed formation.

SHADE TREE PESTS

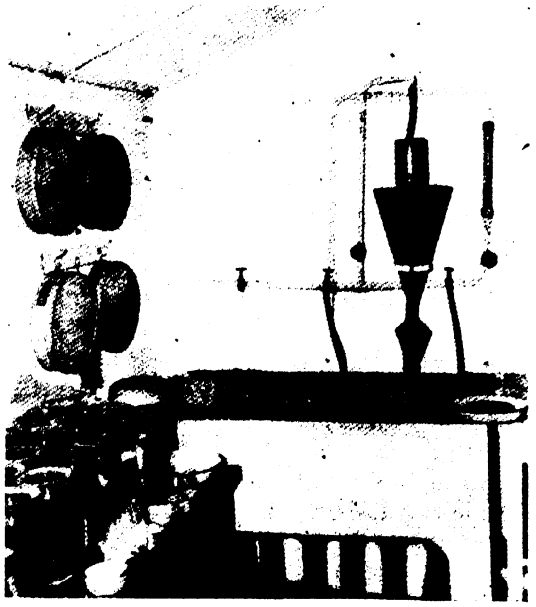
Shade tree canker : Larval populations of *Agrilus beesoni* Obenberger were abundant in the cankerous stems during January to March and again from September to December. Overlapping of different larval instars was common. In laboratory experiments, incubation, total larval and pupal periods were 10 to 15, 120 to 150 and 10 to 15 days respectively. The life cycle was completed in about 4 to 5 months within excised branches of *Albizzia odoratissima*. Maximum adult emergence in the field took place during March to April.

The adults and grubs from the field were found frequently parasitized by *Tetrastichus* sp. (*Eulophidae: Hymenoptera*) and by parasitic nematodes of the family *Sphaerulariidae*. These parasites might be partly responsible for the low viable populations in some months.

A hitherto unrecorded species, *Agrilus* sp. nr. *babaulti* Thery has been isolated from the cankerous stems of *Albizzia lucida* and *A. chinensis*.

NEMATODES

Life-cycle of root knots : The life cycles of *Meloidogyne* spp were worked out with reference to



Elutriator used for extracting eelworms from soil sample.

the distribution of the larval stages in tea roots and soils. Egg masses were deposited by the adult females within the root galls. The first stage larvae stayed within the eggs and only in their second stage did they leave the roots. Next they entered fresh roots at the root tips and started feeding inside. After the second moult the larvae reached their third stage and by this time galls appeared on the roots. At the end of the fourth stage reproductive organs were conspicuous. The males then left the roots to fertilize the females in the soil . The life cycle was completed in 4 to 5 weeks and the pattern was similar for all the four *Meloidogyne* species.

The infective second stage larvae were found in the soil throughout the year, but a peak was noticed during June to July.

Pathogenicity and distribution of root lesion nematodes : Inoculation of two year old seedlings with 20 to 30 root-lesion nematodes (*Pratylenchus brachyurus* Godfery 1929) per plant produced typical damage symptoms within 10 weeks : these were the gradual yellowing of the leaves and development of deep red wounds on the roots. The growth of the damaged roots decreased in comparison with the continuing growth of the uninfested roots.

Though less numerous than the root-knots, these nematodes were present in odd patches in the soil throughout the year. Their numbers increased from March and a population peak was reached during June to August. Thereafter the population declined.

Distribution of Pin-nematodes in mature tea : The ectoparasitic Pin-nematodes (*Paratylenchus* spp) were found around the roots of 25 year old tea. They were distributed mostly in the upper 30 cm of the soil where the roots are concentrated. Although their pathogenic effects were neither clear nor easy to demonstrate, the proximity of these eelworms to root zones indicated that they could be of some consequence in root functioning.

Population of Pin-nematodes increased from January to March after which they declined. The minimum numbers in 100 gms of soil in November was 150 and the maximum in March was 4,500.

Nematodes in shade tree nurseries : *Rotylenchus*, *Criconemoides* and *Tylenchus* were common in shade tree nursery soils, particularly in the presence of *Albizzia odoratissima*. Their pathogenic effects were not immediately clear. Curiously, root knots (*Meloidogyne* spp) and root lesions (*Pratylenchus brachyurus*) were relatively rare.

Nematode survey in Darjeeling : Soils from mature tea sections at different altitudes had the following as dominating groups, though overlapping was common.

Altitude (*metres*)	*Important Groups*
1350 & above	*Rotylenchus*, *Pratylenchus* and other *Tylenchids*.
1200	*Tylenchus*, *Hoplolimus*, *Pratylenchus*.
1050	*Meloidogyne*, *Helicotylenchus*.
900	*Paratylenchus*, *Tylenchorhynchus*.

SOIL BIOLOGY

Insecticides and soil fauna : Soil applications of Endrin 20 E. C. (0.02%), and Dieldrin 18 E. C. (0.018%) reduced the numbers of ants, staphylenid beetles and grubs. With Rogor 40 E. C. (0.082%), Malathion 50 E. C. (0.1%) and Ekatin 25 E. C. (0.05%) the effects were however, not as pronounced. Since these compounds de omposed quickly in the soil, the insect fauna was restored very soon, but not in Dieldrin and Endrin treated plots.

A group of nematodes extracted from a sample of tea soil.

Mycology Department

Red Rust

Studies were continued on the effects of altering the conventional time of spraying against Red rust using a standard copper formulation. It has been observed that Red rust produces spores in large numbers until the middle of July (see below under 'Aerobiology') and as such, the conventional spraying, which is completed in two rounds at fortnightly interval by the end of May, is not considered sufficient to control the disease. To study the effects of prolonged spraying on the incidence and progress of Red rust, Blitox, a copper oxychloride at 0.25% concentration, was applied until the end of September at different intervals in 1968. The spraying was done using pressure retaining knapsack sprayers which are hand operated. Red rust incidence was observed thereafter in May 1969.

It was found that the application of one round or two rounds at two weekly intervals during May did not offer adequate protection though two rounds at monthly intervals beginning from mid May resulted in a significant reduction of the disease. Three rounds at monthly intervals starting from mid May was significantly better than two rounds at monthly intervals. Application of four rounds at monthly intervals from mid May onwards, afforded very good control but the application of a fifth round, one month later did not yield any significantly better result.

Fycol 8 ET a fungicide claimed to be more persistent than any other copper fungicide, was tested side by side with Blitox in single and divided doses using 5 kg per hectare for each treatment. Application was made with a Fontan type of a sprayer by the Pesticides Department in 1968 (reported earlier) using 100 litres of spray fluid per hectare.

Both Fycol 8 ET and Blitox gave significant reduction when applied for twelve rounds at fortnightly interval starting from mid May but Blitox applied in six, monthly, rounds gave significantly better protection than Fycol 8 ET applied at the same rate.

Nine chemical formulations, namely Simazine (Tata Fison), Benlate (Du Pont De Nemours & Co.), Fycol 8 ET (Tata Fison), Neetryl (S. D. C. Pesticides Ltd., Norfolk), Blitox (Tata Fison), RH 90 (Far East Chemical Services Inc.), T. M. T. D. (Thyride-I. C. I.), Brestanol (Hoe 2872, Hoechst Pharmaceutical Ltd.), Emulsifiable copper and Liquid paraffin (Bharat Pulverising Mills) were sprayed on to Red rust affected tea under the field conditions to assess their efficacy in controlling Red rust during the sporulating phase. Two rounds of spray were given, one during mid May and the other, two weeks later. Except for Blitox, none of the new products tested were found promising.

Thorny Stem Blight

The effects of NPK manuring on the development of Thorny stem blight was studied in an experiment conducted by the Darjeeling Advisory Branch. No significant reduction of the disease was noticeable in any of the treatments.

Assessment on the incidence of Thorny stem blight was continued in plots receiving copper fungicide + Indopaste, Indopaste alone, Fungicide S-6422 (Santar A), Copper fungicide 1%, Nickel chloride 1%, Ziram 0.25% and no treatment, immediately after heavy pruning. Results are given in Table 1.

Indopaste with or without Copper fungicide and Fungicide 6422 offered similar control. The observation will be continued.

Table 1 : Showing the effects of different treatments on the development of Thorny stem blight

Treatments	Incidence of disease per plot
Copper fungicide + indopaste	7.17
Indopaste	8.67
Fungicide 6422 (Sandoz)	8.83
Copper fungicide 1%	10.83
Nickel chloride 1%	12.00
Ziram 0.25%	11.00
Control (No treatment)	14.00
C. D. at p 0.05	2.09
C. V.%	17.14

Black Rot

Seven chemical formulations viz. Simazine, Benlate, Fycol 8 ET, Nectryl, Blitox, RH 90 and T. M. T. D. were sprayed in the field against Black rot caused by *Corticium invisum* and *C. theae*. Of these, Blitox at 0.25% concentration gave the best control of the disease followed by Fycol 8 ET which was applied at a higher concentration (0.5%). There was however severe scorching following the application of Fycol 8ET.

Application of two more rounds of Blitox in the Black rot experimental plots in the North Bank (last year the plots were treated with Blitox in two rounds in May and June) during the prophylactic period (1969) resulted in further reduction of the disease and higher yield returns. The yield data for 1968 is also given in Table 2 for comparison. The yield data for each plot during the plucking rounds over the season were collected by our North Bank Advisory Branch.

Table 2

Treatment	1968			1969		
	Yield in kg green leaf per 40 bushes	Yield in kg/ha made tea	% increase over control	Yield in kg green leaf per 40 bushes	Yield in kg/ha made tea	% increase over control
Blitox 1 in 400 with knapsack	29.5	1807.1	9.7	34.1	2088.8	18.8
Blitox 2.5 kg/ha with Fontan	29.6	1813.2	10.0	32.6	1997.0	13.6
Blitox 4.5 kg/ha with Fontan	29.0	1776.4	7.8	32.8	2009.2	14.3
Control (No. spraying)	26.9	1647.8	—	28.7	1758.1	—
C.D. at p=0.05	2.0				1.8	
C. V. %	5.7				4.5	

The table shows the beneficial effects of long term prophylactic spraying in case of a disease like Black rot which persists on bushes from year to year and destroys the maintenance leaf area during the growing season. The spraying operations are profitable.

Purple Root Rot

An experiment was laid in 1967 on a garden on the North Bank to study the effect of chemical treatments on the development and progress of Purple root rot, a primary root rot disease on tea caused by *Helicobasidium compactum*. The following treatments were applied in 1967 only, as soil applications :

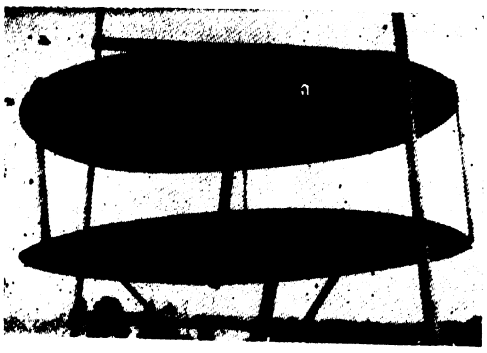
1. Ziram 1% solution 400 ml
2. Brassicol 1% 400 ml
3. Copper sandoz 1% 400 ml
4. $CuSO_4$ 0.5% 400 ml
5. Control.

No mortality has been observed until date even in the control plots. Though this disease has been diagnosed in 1965, no death has so far occurred. The

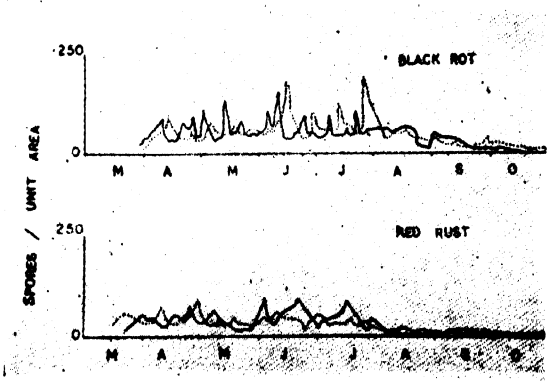
causal organism was identified to be *Helicobasidium compactum* by the Commonwealth Mycological Institute, Kew, England.

Aerobiology

In 1969 both Red rust and Black rot appeared in tea a little later than in 1968. The spores of both the diseases were daily trapped using the Durham trap. Recordings indicated that the spores are dispersed into the atmosphere for much longer periods



Durham Trap.



Showing the daily trapped Spore number between March and Octobor 1969
— —Tocklai
.....Nagrakata

after the conventional spraying with copper fungicide had stopped. This was rechecked with the Red rust experiment referred to earlier in which prolonged spraying has mitigated the Red rust incidence. From these results it is concluded that spraying should continue at least until the end of July which conforms with the results reported above under the heading of 'Red rust'.

Spore trapping made at the Nagrakata Station have also a similar trend but tend to change in the magnitude of the spores, depending upon the climate.

Shade and Nutrients Experiment BAS 204 (Murmuria)

This experiment was laid out by the Botany Department in 1966 to study the effect of shade and nutrients on different aspects of tea cultivation. The field treatments are described in the Entomology report. The Mycology department observed and assessed the effect of shade and nutrients on the incidence and progress of the important leaf cum stem diseases, viz. Red rust and Black rot. Incidence of the diseases was observed from April till August each year commencing from 1966.

Red rust development was not significantly affected in 1966 either by shade or nutrients. This is perhaps because of the short time interval between the removal of shade and the onset of the disease. In 1967 the disease was significantly lower in the shaded regions as compared to the unshaded, but the manurial or nutrient treatments had no significant effects. Results observed in 1968 indicated the same trends. In some of our earlier experiments potash mitigated the Red rust incidence significantly in soils deficient in available potash.

Black rot during the years 1966, 1967 and 1968 was not influenced significantly either by shade or the nutrients. It appears that this disease is more affected by the circulation of air than the actual shade stand *per se*. 1969 results are under analysis.

A New Disease of *Indigofera teysmanii*, Miq.

A new fungus causing leaf spot disease of *Indigofera teysmanii* Miq. was identified and described as *Cercospora teysmanii* G. C. S. Barua *et* K. C. Barua. This disease is manifested by the appearance of minute, circular to sub-circular spots on both the surfaces of the leaflet. These spots increase in size gradually

Indigofera teysmanii leaves affected by leaf spot caused by *Cercospora teysmanii*

and develop into sub-circular to irregular spots which are brown with greyish centre on the upper surface, brown to olivaceous brown on the lower surface. They often coalesce and form larger necrotic patches.

The disease persisted on the leaflets till they were naturally shed. By the end of March a few remaining leaflets still carried the disease but the new growth was found to be completely free from it and remained so till early October.

Pesticide Department

Screening of Pesticides

During the year, the department concentrated its activities on the evaluation of new acaricides/insecticides. Field trials on the joint action of compounds (acaricides/insecticides) as a prophylactic measures is reported and discussed. The control of shade tree pest and a trial with new insecticides having low mammalian toxicity against looper caterpillar, are reported. In addition the data for last three years (1967-1970) on the spraying trials with combined sprays as a palliative measure were collated and are reported. A new Rain-machine fabricated in Tocklai is described.

Acaricides

Combined Spraying Trials (Prophylactic)

It has been demonstrated through repeated trials that a persistent acaricide remains biologically potent for a long period, progressively decreases the pest population and ultimately acts as a prophylaxis to prevent subsequent reinfestation of the pest. Field trials over the past years have shown that prophylactic spraying is the most effective measure to prevent build up of a potential population of red spider and other mites. It has been established beyond doubt that due to the acceptance of prophylactic spraying the incidence of damage due to red spider and other mites has gone down considerably and the percentage of 'avoidable loss in crop' has been minimised.

Until now a single chemical spray was recommended against a single pest as prophylactic spray. But as it has already been pointed out (Ann. Rept. 1967/68) that there are areas in every estate which are not only prone to one mite but sometimes a combined infestation of two or more mites or insects at once have been noticed.

In view of this, prophylactic trials were carried out in Assam where different chemicals were mixed together at different quantities and sprayed in an area prone to different mites and also mites and insects.

Joint Action of Acaricides

Field Trial No. 1 : A field trial was laid out in a section of mature tea where red spider, scarlet and pink mites were simultaneously present. The treatments were applied with a mist blower (Fontan type) and the combination of acaricides used and their rates of application were :-

a. Ethion + Morestan at 0.5 l/ha + 0.5 l/ha respectively
b. Ethion + Morestan at 0.3125 l/ha + 0.3125 l/ha respectively.
c. Tedion + Morocide at 0.5 l/ha + 0.5 l/ha respectively
d. Tedion + Morocide at 0.5 l/ha + 0.3125 l/ha respectively
e. Tedion + Trithion at 0.5 l/ha + 0.5 l/ha respectively
f. Tedion + Trithion at 0.3125 l/ha + 0.3125 l/ha respectively
g. Ethion at 1.25 l/ha
h. Morestan at 1.25 l/ha
i. Tedion at 1.25 l/ha
j. Morocide at 1.25 l/ha
k. Morocide at 1.25 l/ha

The result was very encouraging. It was found that the mixtures of two acaricides (treatments a, b, c, d, e and f) when used at the rate of 0.5 l/ha and 0.3125 l/ha of each respectively were equally effective as when the same chemicals were used singly at their recommended doses (treatments g to k) and they remained active for a period of 3 months after single spray in the third week of February.

Joint Action of Acaricides and Insecticides

The results of the mixing two acaricides as a prophylactic spray for control of mixed population of different mites have been discussed in foregoing text. It is well known fact that there are areas in estates which harbour a potential population of red spider and other mites and insects such as scales.

These areas are the foci for future infestation in larger scale and as such it was decided to try the effects of acaricides mixed with insecticides.

Field Trial No. 2 : This trial was located in a section where there was a combined infestation of red spider, scarlet mite and scale insects. The treatments were applied with a mist blower and the acaricide/insecticide mixtures used with their rates of application were :-

a. Morocide + Morestan + Malathion at 0.375 l/ha + 0.375 l/ha + 2.5 l/ha respectively.

b. Morocide + Morestan + Malathion at 0.25 l/ha + 0.25 l/ha + 1.25 l/ha respectively.

c. Tedion + Trithion + Malathion at 0.375 l/ha + 0.375 l/ha + 2.5 l/ha respectively

d. Tedion + Trithion + Malathion at 0.25 l/ha + 0.25 l/ha + 1.25 l/ha respectively

e. Ethion + Morocide + Malathion at 0.375 l/ha+0.375 l/ha + 2.5 l/ha respectively

f. Ethion + Morocide + Malathion at 0.25 l/ha + 0.25 l/ha + 1.25 l/ha respectively

g. Ethion + Malathion at 1.25 l/ha + 2.5 l/ha respectively

h. Tedion + Malathion at 1.25 l/ha + 2.5 l/ha respectively

i. Morestan + Malathion at 1.25 l/ha + 2.5 l/ha respectively.

j. Trithion + Malathion at 1.25 l/ha + 2.5 l/ha respectively.

The result was excellent and it was found that for the control of a mixed infestation of red spider, scarlet mite and scales in a section of tea a combined spray of two acaricide and one insecticide (treatments a to f) when used at the lower doses were highly effective.

So far the result of these two experiments are encouraging and they suggest that the effects of the joint action of three acaricides or a mixture of acaricide against a combined infestation of two or more mites or mite and insect can be as effective and economical as a prophylactic spray.

New Acaricides

New acaricides, Lovozal 20 W, Furadan 75 W. P., Zolone 35 E. C., Kilval 40 E. C., Acrex 30 E. C., HOE 6021 (E. C. and Paste) and Azodrin were evaluated against red spider for their effectiveness as palliative sprays. The treatments were applied with a mist blower at the rate of 1.25 l/ha each. Tedion and Ethion were used as a standard for comparison. None of these new compounds proved better than Tedion or Ethion, but Azodrin which was equitoxic and gave 94% kill of the mites after one month of application. Furadan and Zolone showed promise and the percentage mortality of mites was 85 and 84 respectively.

In another experiment, Tedion V-18, Ethion 50 E. C., Morocide 40 E. C. and Morestan were evaluated against red spider at three doses c. g. at (a) 1.25 l/ha (recommended), (b) 1.00 l/ha and (c) (0.75 l/ha. The percentage mortality of mites after one month of application at three doses mentioned above were Tedion-96, 90, 81 respectively; Ethion--95 72 53 respectively; Morocide- 82, 56, 41 respectively; Morestan - 91, 53, 40 respectively. This experiment was carried out in the month of May 1969 and the total rainfall during this period was 174.1 mm (6.85"). Thus it was proved that hitherto the dose recommended i. e. 1.25 l/ha for use of Tedion, Ethion and Morocide against mites is correct.

Combined Spraying Trials (Palliative) 1967-1970.

Rising costs and the need to increase productivity are as applicable to the tea industry as to any other. The cost of pest control in tea has gone up as has any other agricultural operation. While competitively priced pesticides of high inherent activity are helping to improve the efficiency of pest control, there is much scope for effecting further economies by improving methods of application. One, which has been investigated since 1967-68, is the use of combination of compounds having similar physiological effects on different pests. Apart from the economy in operation, a mixture may be useful in controlling a mixed population of mites and insects if one species is very susceptible to one component and another species to a second

Keeping the above points in view and also because it is a fact that tea bushes in almost all tea growing areas in N. E. India are simultaneously attacked by different mites and insects, a series of field trials were started in 1967-68 through 1969-70, in Assam, the Dooars, Terai and Darjeeling using different chemicals mixed together in different quantities.

The results of the three years' trial are collated and are presented in Tables 1 and 2. The experiments have proved that a special effect such as 'synergism' has made the mixtures especially lethal (potent) even at lower doses than the usually recommended dose of application, and so brought about more economic control than by one active ingredient alone. It has also proved that a combination of a more rapidly acting but less persistent compounds such as Trithion, Morestan and Malathion with less rapidly acting but more persistent compounds such as Tedion, Ethion, Morocide, Kelthane and Thiodan permitted more favourable control than by one single compound.

Table 1: Different combination of compounds (acaricide/acaricide) used against combined infestation of mites (red spider, scarlet, pink and purple mites)- 1967-70.

Year	Treatments	Rate of application Litre/kg per ha	Observation after 1 month Percentage of mortality of			
			Red spider	Scarlet mite	Pink mite	Purple mite
1967/68	Tedion + Kelthane + Rogor	0.375 + 0.375 + 1.25	92	100	90	
	" + " + "	0.625 + 0.625 + 0.625	100	100	98	
	Ethion + Kelthane	0.625 + 0.625	97	100	98	
	" + "	0.3125 + 0.3125	99	91	95	
	Tedion + Kelthane	0.625 + 0.625	100	100	98	
	" + "	0.3125 + 0.3125	97	91	96	
	Kelthane + Akar	0.625 + 0.625	98	100	97	
	" + "	0.3125 + 0.3125	96	100	95	
1968/69	Ethion + Morestan	0.5 + 0.5	100	94	97	
	" + "	0.3125 + 0.3125	86	91	74	
	Tedion + Morocide	0.5 + 0.5	100	90	91	
	" + "	0.3125 + 0.3125	82	91	78	
	Tedion + Trithion	0.5 + 0.5	100	93	92	
	" + "	0.3125 + 0.3125	86	91	74	
	Ethion + Morestan	0.5 + 0.5		96	99	100
	" + "	0.3125 + 0.3125		93	90	99
	Morocide + Ethion	0.5 + 0.5		93	90	99
	" + "	0.3125 + 0.3125		90	94	98
	Ethion + Trithion	0.5 + 0.5		93	95	99
	" + "	0.3125 + 0.3125		90	90	98
	Morocide + Morestan	0.5 + 0.5		97	99	98
	" + "	0.3125 + 0.3125		95	97	100
1969/70	Ethion + Morestan	0.2 + 0.2	92	91		87
	" + "	0.15 + 0.15	72	86		45
	Morocide + Trithion	0.2 + 0.2	94	88		87
	" + "	0.15 + 0.15	87	79		46
	Ethion + Morocide	0.2 + 0.2	97	90		84
	" + "	0.15 + 0.15	88	80		49
	Morocide + Morestan	0.2 + 0.2	91	96		89
	" + "	0.15 + 0.15	78	83		43

The tables give a range of doses tried as a mixture of compounds and the best dose for the control of red spider and other mites has been found to be 0.5 l/ha + 0.5 l/ha, though lower doses have also been found quite satisfactory. In case of a mixture of acaricide/insecticide the best doses has been found to be - (1) for mites/scales-0.375 + 0.375 + 1.25 l/ha (2) for mites/thrips-0.375 + 0.375 + 0.625 l/ha though other doses have also been found to be satisfactory.

No attempt has been made to find out the exact economy in material and operational cost by mixing compounds, but it is envisaged that there will be a saving of 20 to 30% in the cost of pesticide depending on the acaricide used and about 33% in the cost of labour per hectare of tea.

Table 2 : Different combination of compounds (acaricide/insecticide) used against combined infestation of mites and insects (red spider, scarlet, purple mites, scales and thrips)- 1967-70

Year	Treatments	Rate of application Litre/kg per ha	Observation after 1 month Percentage of mortality of				
			Red spider	Scarlet mite	Scales	Thrips	Purple mite
1967-68	Tedion + Kelthane + DDT	0.375+0.375+1.25	100	100		86	
	Tedion + Kelthane + DDT + Rogor	0.625+0.625+0.625+0.625	100	100		61	
1968-69	Morocide + Morestan + Malathion	0.375 + 0.375 + 2.5	100	88	92		
	" + " + "	0.25 + 0.25 + 1.25	99	88	97		
	Tedion + Morocide + Malathion	0.375+0.375+2.5	100	92	97		
	" + " + "	0.25 + 0.25 + 1.25	99	93	97		
	Ethion + Morocide + Malathion	0.375 + 0.375 + 2.5	100	80	92		
	" + " + "	0.25 + 0.25 + 1.25	96	75	95		
1968-69	Tedion + Ethion + Malathion + Thiodan	0.375 + 0.375 + 2.0 + 0.625	97		98	100	
	" + " + " + "	0.2 + 0.2 + 1.25 + 0.3125	93		95	91	
	Tedion + Morocide + " + "	0.375 + 0.375 + 2.0 + 0.625	93		95	93	
	" + " + " + "	0.2 + 0.2 + 1.25 + 0.3125	90		92	84	
	Tedion + Malathion + Thiodan	1.25 + 2.9 + 0.625	96		98	97	
	Ethion + " + "	1.25 + 2.0 + 0.625	95		97	97	
	Morocide + " + "	1.25 + 2.0 + 0.625	94		96	97	
1969-70	Tedion + Trithion + Thiodan + Malathion	0.3 + 0.3 + 1.5 + 0.5	86		97	95	
	Ethion + " + " + "	0.3 0.3 + 1.5 + 0.5	62		91	76	
	Kelthane + " + " + "	0.3 + 0.3 + 1.5 + 0.5	90		98	88	
1969-70	Kelthane + Morocide + Thiodan	0.5 + 0.5 + 1.25		96		92	99
	Kelthane + Trithion + Thiodan	0.5 + 0.5 + 1.25		99		88	96
	Kelthane + Ethion + "	0.5 + 0.5 + 1.25		99		95	99

Insecticides

Control of Canker of Shade Trees

Field trial against *Agrilus beesoni* which produces canker in shade trees, was once more repeated this year using new insecticides. Dieldrex and Thiodan were used as standards for comparison. The percentage recovery from canker of shade trees treated with Dieldrex, Thiodan, Sumithion, Furadan and

Kilval sprayed at 2.5 l/ha over the untreated plants were 95,91,91.92 and 85 respectively.

Control of Scales

In recent years scales have attained status of a major pest in Assam, the Dooars and especially in Darjeeling. Malathion and Rogor have been fully used so far but their persistence is low. New persistent insecticide such as Basudin, Furadan, Kilval, Zolone and Malathion U. L. V. were tried at 1 25 l/ha and Malathion U. L. V. at 1 l/ha. The percentage mortality after 1 month of application was 90, 98, 92 90 and 96, respectively.

Control of Looper Caterpillar

The problem of toxic residues has markedly limited the choice of insecticide for application to tea in plucking. Since the use of DDT, Endrin and other organochlorines have been restricted, Thiodan is the only insecticide used for the control of looper caterpillar. For this reason a comprehensive search for less toxic but potent materials has been continued. Recently some potent insecticides such as Gardona 44 E. C., Sumithion 50 E. C. and Dursban 10 E. C., having low mammalian toxicity (Acute oral LD 50 ranging between 500 to 5000 mg/kg body wt.) were successfully tried against looper caterpillar. Gardona and Sumithion were applied at 1.25 l/ha with a mist blower and compared with Dursban and Thiodan at 2.5 l/ha. The percentage kill of looper after 1 week of application of Gardona, Sumithion, Dursban and Thiodan was 92, 95, 92 and 99 respectively.

Fungicides

Copper for spraying tea is used as copper oxychloride or cuprous oxide and these are not very tenacious or rain-fast, which is a considerable disadvantage in areas of high rainfall. The peak period of red rust and black rot infestations in tea is from May to August i. e. the period when we get the highest precipetation. In the field during the rains, copper gets quickly washed away and hence most of its fungi-toxicity is lost.

'Rain-fastness' of fungicides can be improved by using 'additives' like lanolin to solid fungicides dispersed in water or by disolving the fungicide in wax or lanolin and then emulsifying the solution. Wax and lanolin acts as viscous stickers suitably increasing the 'rain-fastness' of deposits on leaves. In order to screen 'rain-fastness' or 'tenacity' of fungicides, an artificial rain making machine has been fabricated in Tocklai. The idea is to see to what extent the deposit will be washed down by a fixed amount of water applied in equivalent of rainfall in mm/hour and so decrease the 'tenacity'.

Artificial rain making Machine

This machine imitates heavy rain i. e. 200 mm (8 inches) of rain in one hour. Detached leaflets are fixed with rubber bands to 7.5 cm (3 inches) panels at the bevelled rim of 75 cm (30 inches) wheel rotating at 6 rev/min. As the wheel rotates, the leaflets pass through the jet of water from a coarce T-jet held 15 cm (6 inches) away from and at right angles to the panel passing under it. Each leaflet receives the same amount of heavy 'rain' (about 16.5 mm (0.66 inches) in 5 minutes). Tests on the tenacity of different formulations of copper fungicide are in progress.

Nematicides

Temik 10 G, which was reported last year and a new formulation Lannate 90% W were tried and compared with Nemagon on a member's estate.

Analysis of the results showed that the percentage of plants free from root-knot infestation were significantly higher and root-knot indices were significantly lower in Nemagon and Timik 10 G treated plots than the untreated control plots. The number of seedlings which reached plantable size were greater in Nemagon and Timik 10 G treated plots than the untreated control plots. Lannate 90% W did not show any promise.

Taints of Made Tea due to Pesticides

Malathion (I. C. I.), Trithion (B. M. C.), HOE 6021 were tested to find out whether they taint made tea when sprayed at recommended doses. None of the chemicals imparted any taint to made tea.

Residues

Field trials were conducted during dry and wet weather conditions to evaluate residues of Trithion HOE 6012, HOE 6021, Chlorobenzilate, Chloropropylate and Bromobenzilate.

Certification of Pesticides and Herbicides

During the year 15 new products were received for official testing. Certificate of approval for 10 products were issued and 24 Certificates were renewed.

Biochemistry Department

Biochemical Differentiation of Clones

An experiment was conducted to see whether differences in the liquor characters of clonal teas detected by the Tea Taster would reflect in simple biochemical attributes like enzyme activity and total oxygen uptake of green leaf and total condensed polyphenols (TF + TR) of the corresponding Orthodox and C. T. C. teas.

Four Tocklai vegetative clones of known liquor characteristics and cash valuations viz. 3/77, 20/23/1, 19/29/13 and 1/7/1 were selected for the purpose and their enzyme activities, total oxygen uptakes and condensed polyphenols were determined from May to November on 12 occasions. The results are summarised in Table 1.

Table 1 : Enzyme activity, total oxygen uptake and total condensed polyphenols (TF & TR) of C. T. C. and Orthodox teas of clones 3/77, 20/23/1, 19/29/13 and 1/7/1. Average for the whole season.

Source clone	Enzyme activity (QO_2) μl/mg/hr	Total oxygen uptake μl/mg/2 hrs	Total condensed polyphenols (TF + TR)%		Biochemical order of preference	Tasters order of preference based on valuation
			C. T. C.	Orthodox		
3/77	15.95 ± 1.54	9.37 ± 0.58	17.21 ± 1.72	10.65 ± 1.05	4	4
20/23/1	19.47 ± 1.47	10.78 ± 1.18	19.82 ± 1.78	13.12 ± 1.17	2	2
19/29/13	19.78 ± 1.44	12.09 ± 1.01	21.99 ± 2.3	13.83 ± 1.13	1	1
1/7/1	16.09 ± 1.37	10.70 ± 0.80	19.83 ± 1.29	11.83 ± 0.63	3	3

It was observed that preferences based on these three biochemical estimations agree with the Taster's ranking of the clones. These simple biochemical observations may therefore provide an objective basis for differentiating clones used for producing non-flavoury N. E. Indian plains teas.

Studies on Enzyme Activities

Enzyme activities of fresh leaf and C. T. C. and Orthodox made teas, were measured and it was found that C. T. C. and Orthodox teas retain about one-tenth and one-twentyth enzyme activity, respectively, of the fresh leaf.

The inhibition of residual enzyme activity of made tea was observed with potassium cyanide and sodium fluoride solutions, and the degree of inhibition due to sodium flouride was more than that of potassium cyanide. The auto-oxidation of sodium flouride was also negligible.

The residual enzyme activity of tea powder heated at 95°C for one hour dropped to one fourth of the activity observed before heating. No enzyme activity of acetone washed tissues from fresh, fermented and made teas could be detected after dipping in boiling water for 2 minutes.

Fresh leaf dried at 40°C for 48 hours lost approximately 90 per cent of its enzyme activity. Leaves of clone 19/29/13, dried at 40°C, retained only 2.02 μl/mg/hr activity, whereas activity of the same leaf dropped to 0.14 μl/mg/hr when dried at 90°-95°C for 45 minutes.

At one time we were worried about the residual enzyme activities of our freshly manufactured teas, as the enzyme might remain active to cause deterioration of the teas in storage.

However, analysis for the enzyme content of 44 unblended tea samples procured from different tea producing countries of the World including India showed that the enzyme activities of these teas were less than freshly manufactured teas examined previously. This shows that the residual enzyme contents of our teas after storage are neither better nor worse than those of the teas of other countries. Thus the enzyme activities of teas disappear gradually with time and storage.

Soluble Protein in Tea Infusion

One hour tea infusion, after removal of free amino acids (except leucine and isoleucine) with resins, was hydrolysed with N Hcl for 12 hours on a water-bath and then examined chromatographically. The hydrolysate was found to contain the following amino acids : serine, asparagine, glutamic acid, lysine, glutamine, threonine, alanine, tyrosine, valine, besides leucine and isoleucine in greater concentrations. The unhydolysed resins treated extract did not contain any amino acids except leucine and isoleucine in small concentrations.

Thus soluble nitrogen of tea infusion contains some soluble proteins as well as caffeine and free amino-acids.

Keeping Quality of Made Tea

In the latter part of the manufacturing season Orthodox and C. T. C. manufactures were made of leaf drawn from two sources :- clones 20/23/1 and 19/29/13. The teas were stored under three different conditions in aluminium sample containers sealed with cellotape, Viz. at room temperature (range 19°- 36°C), in an airconditioned room (19°-22°C) and in an ice-box (0-5°C).

The teas were analysed at the 4th, 8th, 16th and 24th week, for TF, TR, Cream Index, EGCG, ECG, TG, residual enzyme activity (QO_2), residual oxygen uptake and valuation. The control samples were analysed on the day of manufacture.

No appreciable loss in enzyme activity and residual oxygen uptake was observed in teas stored at ice-box temperatures. However, loss of residual enzyme activity and residual oxygen uptake was recorded for both C. T. C. and Orthodox teas stored at room and air-conditioned temperatures.

An increase in TF was noted with time of storage in Orthodox teas almost by the same proportion under all storage conditions, but in C. T. C. teas, TF increased in the order of :-

(1) ice-box
(2) air-conditioning
(3) room temperature

in comparison with the control. TR did not change with the time of storage in both Orthodox and C.T.C. teas.

Cream index of C. T. C. teas is always higher than that of Orthodox tea assuming equivalent source materials. Gradual increase in creaming was noted in Orthodox and C. T. C. teas from 4th to 24th week. Slight decrease in concentration of EGCG, ECG and TG was observed during the above periods for the teas.

The teas were tasted periodically by our Tea Taster but the valuations have not been very conclusive. However, further study is under way.

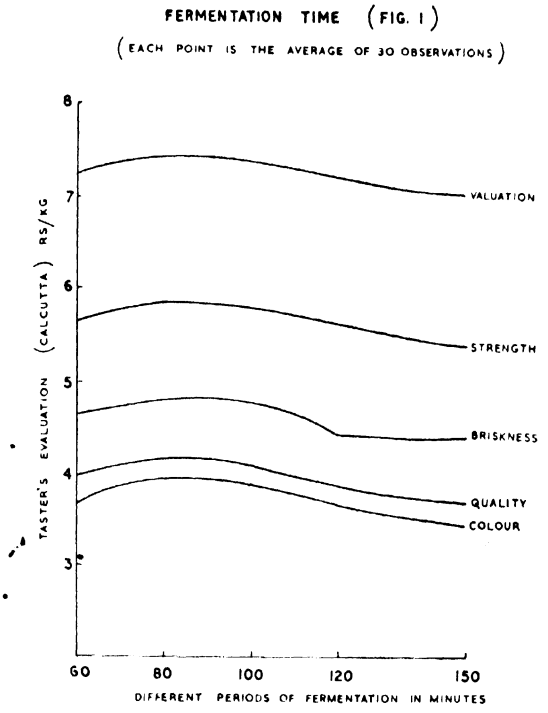
Fermentation Time

Experiments relating to the changes in cup-characters of C. T. C. teas, fermented for different lengths of time viz. 60 min, 80 min, 100 min, 120 min and 150 min. were carried out. For this purpose five leaf sources were selected :- Tingamira, Betjan and three clones, 19/29/13, 20/23/1 and 106/1,.

The object of this experiment was to attempt to correlate taster's valuations at different periods of fermentation with the scores for colour with milk; strength of liquor; briskness and quality.

One kg sample of fresh leaf from each of the five sources was manufactured weekly: a total of 30 sets being manufactured in the course of growing season, making in all 150 samples. The teas were submitted to the Tocklai Tea Taster and the Calcutta tasting

panel for evaluation. A fermentation period of 80 min. was considered best by the Calcutta panel in respect of the different liquor characters and cash valuation (Fig. 1).



Fortification of Tea With Lysine and Vitamin

Lysine

Fortification of tea with lysine was conducted on a commercial scale at Ghilladhary and Deha Tea Estates. The method evolved was successful and the equivalent of each 3 gms of tea was fortified with 96 mg. of lysine.

A taster's infusion was made with this fortified tea and analysed spectrophotometrically for lysine. More than 80% lysine was recovered from this tea brew.

Vitamin A

Three different concentrations of Vitamin A in water, (20000 I. U./kg green leaf, 40000 I. U./kg green leaf and 80000 I. U./kg green leaf) in the forms of Vitamin A palmitate with antioxidant (dry powder), Vitamin A acetate (an emulsion) and Vitamin A palmitate (dry powder) were sprayed on to 1 kg fermented tea particles before it was dried in the drier at the Tocklai miniature factory. Neither the taste nor the valuations of the fortified teas were changed.

The estimated incorporation of Vitamin A (I. U.) /3 gms black tea in different forms is given in the Table 2.

Table 2 : Fortification of tea with Vitamin A

Sample used for spray	Estimated incorporation of Vitamin A (I. U.)/3 gms black tea.
Vitamin A palmitate with antioxidant	Control 300 I. U. 600 ,, 1200 ,,
Vitamin A acetate	Control 300 I. U. 600 ,, 1200 ,,
Vitamin A palmitate	Control 300 I. U. 600 ,, 1200 ,,

Miscellaneous Experiments

(a) Moisture determination of tea leaf particles before drying

Attempts were made to determine the moisture content of whole fresh leaf, whole withered leaf, rolled leaf, C. T. C. fermented leaf and their cut pieces, by using a Kay-bee Infra-red moisture meter with the lamp at the highest position. The percentage moisture content was also determined by the standard oven method. The variation in the moisture content between the two methods was found to be less than 2 per cent as can be seen in Table 3.

The time for determining moisture content was observed to vary with leaf-size and season variations.

Table 3 : Moisture determination of tea leaf particles

Sample	Quantity of leaf	Moisture content(%) by Kay-bee	Moisture content(%) standard oven	Difference between the two methods	Time of exposure for complete removal of moisture
Fresh leaf whole	5 gms	78.0	78.01	0.01	25 to 35 min.
	,,	77.8	77.05	0.75	
	,,	77.5	77.71	0.21	
Fresh leaf, cut into pieces	5 gms	78.01	77.67	0.34	25 to 30 min
	,,	78.0	78.05	0.05	
	,,	79.8	79.58	0.22	
Withered leaf, whole	5 gms	72.0	72.16	0.16	25 to 30 min.
	,,	71.8	72.09	0.29	
	,,	70.2	71.52	1.32	
Withered leaf, cut into pieces	5 gms.	72.0	72.16	0.16	25 to 30 min.
	,,	68.0	68.23	0.23	
	,,	53.5	53.84	0.34	
Orthodox rolled leaf (fermented)	5 gms	70.5	70.73	0.23	20 to 25 min.
	,,	64.5	63.77	0.73	
	,,	64.0	63.77	0.23	
C. T. C. fermented leaf	5 gms	67.5	66.99	0.51	20 to 25 min.
	,,	67.8	66.41	1.39	
	,,	66.5	64.65	1.85	

(b) Analysis for TF and TR on unblended tea samples collected from various parts of the World

44 tea samples both C. T. C. and Orthodox were collected from various tea producing countries of the world and were analysed for TF and TR. The detailed results of TF and TR and their relation with colour and brightness will be published at a later date.

(c) Analysis of Samples

Eleven instant tea samples from Calcutta University and one hundred seventy seven from Advisory Branch, Botany Dept., Research Engineering Dept & various tea gardens were analysed during the year.

(d) Moisture Meters

Eleven Infra-red moisture meters (Kay-bee & N-Foss types) from various tea estates were calibrated during the year.

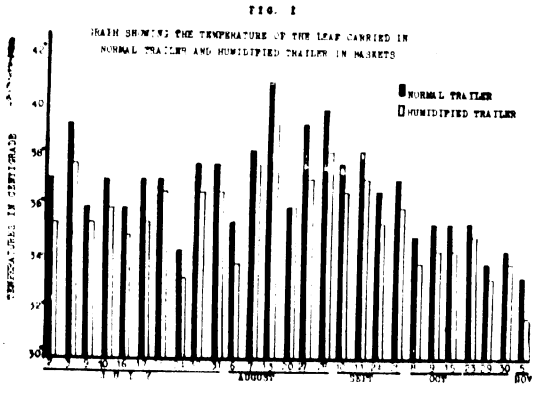
Two Torsion moisture meters from a member garden were sent for calibration and their performance was good.

Manufacturing Advisory and Tea Tasting Department

EXPERIMENTS AT TOCKLAI

Leaf Carriage : It was observed last season using a humidified trailer for transporting leaf that the less the heating of bulk leaf the better was the quality of the made tea. July, August, September and October are the months in N. E. India when most of the teas are made and during this period ambient temperatures are very high

Teas were made in an experimental scale during this period with leaves transported in the humidified trailer and in an open trailer as normally used for carrying leaf from garden to the factory. On each occasion it was observed that tea made from leaf transported in the humidified trailer was superior to tea made from leaf transported in the ordinary trailer, except for one trial on 7. 8. 69. On that date the humidifier fan jammed, resulting in an uncontrolled rise of temperature in the bulk leaf which demonstrates the harmful effect of high leaf temperatures. Figure 1 shows the reduction in temperature obtained in the bulk leaf carried in the humidified trailer compared to the leaf transported in the ordinary open trailer.



During these experiments it was also observed that the type of container normally used by the industry for carrying leaf is far from satisfactory. Putting leaf in baskets about 17 cm high in itself encourages rise in temperature and baskets of half that height should definitely help.

Effect of 8 Groove and 10 Groove C. T. C. Segments : The use of 10 groove segments in C. T. C. rollers instead of 8 groove was suggested in 1969 for the case of sizing the leaf to suit the market. More experiments have been conducted this year and the results show that it is preferable to use 8 groove segments for the first cut, followed by 10 grooves in second and third cuts. This applies for both RV, C. T. C. and Roll C. T. C. types of manufacture. Another important point which was observed was that the angle of the milling cutter for sharpening the 10 groove segments should be set at 70°.

Effect of Field Practices on the Cup Characters of Made Tea :

Agriculture Department

B. 112. 1 Fineness of Plucking : The tea made from leaf plucked on a three day round was the best followed by the tea made from leaf plucked at five days; whilst the tea made from leaf plucked on seven days without breaking back was the worst.

B. 106. 4 Irrigation cum pruning : Tea made during November from leaf plucked from the plots irrigated @ 5 cm of water per month including rainfall was superior to tea made from leaf plucked from unirrigated plots. This shows that in a droughty area irrigation will help not only to produce more crop but better quality of tea also.

B. 102. 1 Forms of Nitrogen in Heavy Doses : Nitrogen applied at 100 kg per hectare did not affect the cup character of made tea but at 200 kg per hectare it had adverse effect on cup characters. Among the forms of nitrogen, calcium ammonium nitrate had the least adverse effect on the cup characters of the made tea followed by sulphate of ammonia and urea.

Field Advisory Department

Short term weedicide trial : No change in cup character was observed due to the application of the following weedicides in areas under plucking :

1. Karmex 2 kg per hectare
   Amitrol 2 kg active per hectare
   Gramaxone 5 c. c. per litre of water.
2. Dalapon 3 kg + Gramaxone 5 ml per litre of water
3. Gramaxone 5 ml per litre of water
4. Simazine 4.5 kg per hectare
   Gramaxone 5 ml per litre of water
5. Cheel
6. 2-4D at 500 g active ingredients per hectare
   750 g Bladex followed by Gramaxone.

AS 77 Sulphate of ammonia with and without lime : Application of lime at 1.0 tonne and 2.0 tonne slaked lime per hectare to areas under plucking in the presence of 100 kg and 200 kg nitrogen per hectare had no effect on the cup characters of the made tea.

AS 56 High Frequency of Application of Sulphate of Ammonia

High doses at 247 kg nitrogen per hectare in single and divided doses seem to affect the cup characters of the made tea adversely.

Botany Department

Effect of Shade on Quality : Teas made from unshaded areas were usually better in cup than the teas made from heavily shaded areas.

It is of interest to note in this context that tea made from leaves plucked from lightly shaded areas and heavily shaded areas sent from commercial estates for tasting showed clearly that heavy shade had a detrimental effect on the quality of made tea.

Pruning Cycle Experiment : In conformity with the results published in the Annual Report for 1968/69, page 89, tea made from pruned clonal bushes were found to be distinctly superior to the teas made from unpruned bushes. The difference was more pronounced during the second flush, less during the rains and almost negligible after mid October.

Grafting : Teas were tasted from clones grafted on one another to observe the effects, if any, of root stocks on scions. Where the root stock was from a clone with not so pronounced character, the taste of the stock was perceptible in cup. In certain cases, however, the combination turned out to be a nice blend in cup e. g. clone 1/7/1 grafted on clone 3/77.

Biochemistry Department

Lysine was added to tea during manufacture in commercial factories and it was observed that it did not impart any taint or change to the taste of the made tea.

Pesticide Testing Unit

Taints : Thirty five departmental samples were manufactured and tasted to ascertain whether the undernoted chemicals imparted any taints :

Malathion 50 E. C. (I. C. I), Trithion 20 E. C. (B. M. C.) Hoe 6012, Hoe 6021, Malathion ULV, Miltox, Colloidox, PP 511, Nickel Chloride (A.M.) Trithion 20 E (Anker), Difolatan, Dikar Dursban, Thiodan ULV.

The teas were manufactured and tasted after about a week from the date of spraying. It was observed that none of the above chemicals imparted any taints.

Residues : Fifty four samples were manufactured for residual testing.

EXPERIMENTS IN COMMERCIAL FACTORIES

Introduction of Oxygen During Rotorvaning : The introduction of oxygen during Rotorvaning in RV/C. T. C. manufacture gave very encouraging results. In the past when oxygen was introduced during manufacture the teas immediately after manufacture were very bright but by the time they reached the market there was hardly any difference left. This season, experiments were conducted at Dem Dima T. E. by introducing oxygen into the Rotorvane during RV/C. T. C. manufacture. From this experiment it was observed that to get the best results, leaf should be withered to 75% and oxygen should be

introduced at 5 litres per minute in a Rotorvane running at about 30 R. P. M. followed by slow and fully drying. This is most important. Teas made in this manner have been observed to preserve their brightness even after six months.

Our recommendation regarding drying of oxygenated tea is that the tea should be dropped with a moisture content of approximately 4-5% in the first fire and drying should be slow in the first fire, say anything up to 20 minutes or more.

Attempts at introducing oxygen in to a three crank roller or during fermentation in a fermenting trough, not only proved to be wasteful but also without any beneficial effect on the made tea.

It is concluded that factories, especially in areas like the Dooars and Cachar, will obtain considerable benefit by introducing oxygen to the Rotorvane in RV/C. T. C. manufacture provided a good wither i. e. 75% can be obtained. With a poor wither the result will not be as good.

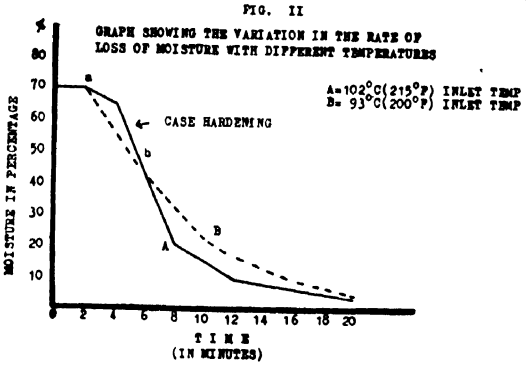
Drying of C. T. C. cut Leaf and its Effect on the Taste of Made Tea

It was observed from experiments carried out at Tocklai that the rate of loss of moisture during drying varies according to different starting moisture contents. The more the starting moisture in the leaf (moisture content varying between 77 and 68%) the higher is the evaporation of moisture in the early drying stages. With very high temperatures 82°C (180°F) below the top tray the rate of loss becomes so rapid that case hardening occurs giving a bitter taste to the tea.

It is a common experience in commercial factories, particularly with C. T. C. teas, that use of high temperatures during drying in the first fire is accompanied by a bitter taste in the tea which sometimes can be confused with briskness. This usually happens when the moisture content of the withered leaf is high i. e. more than 70 per cent. With high temperatures, the rate of evaporation becomes so rapid that a coating is formed by the chemicals present in the juice adhering to the surface of the leaf particles, resulting in obstruction to the rate of loss of moisture as shown by the continuous line from B to C, Figure II. This results in a bitter taste to the teas. The obstruction to the rate of moisture loss, however, is temporary and after sometime this coating is broken by the pressure generated inside the leaf particles due to further heating. After this no further case hardening takes place. Figure II shows the pattern of loss of moisture during case hardening and a normal pattern from a three stage commercial drier as worked out on a commercial estate. The case hardening in this case was obtained by using an inlet temperature of 102°C (215°F) and the temperature below the top tray was about 82°C (180°F) with C. T. C. processed leaf having 72 per cent moisture.

FIG. II

GRAPH SHOWING THE VARIATION IN THE RATE OF LOSS OF MOISTURE WITH DIFFERENT TEMPERATURES



The rate of loss of moisture at the early stage when the leaf particles have a moisture content of between 60% to 80% is very critical and if it can be controlled then there is no risk of the bitter taste developing. It is however not a very simple task to check the rate of loss of moisture all the time in a commercial factory. Also, the rates of loss will vary with varying moisture contents of the leaf and variation of the volume of air.

To produce a full liquoring tea without case hardening and with good keeping quality the recommendation is to confine the temperature underneath the first run of trays (measured in the centre), between 60° to 71°C (140°F to 160°F) in a three stage commercial drier with sufficient air to give a bounce on the fourth run of trays from the top. With wet leaf,

to satisfy the above conditions, it sometimes may be necessary to have a throughput time of anything up to 20-24 minutes with a very thin spread and to drop the teas from the first fire with a moisture content of 4 to 5% using a temperature of 93°C to 99°C (200 to 210°F) at the inlet.

ADVISORY

Pruning Cycle and Quality : We are very often asked from the quality view point if bushes should be pruned, skiffed or left unpruned and should longer pruning cycles be adopted. The following are the conclusions which have been drawn from data collected from a member estate on cost of production and selling price and from the results of our own pruning and tasting experiments.

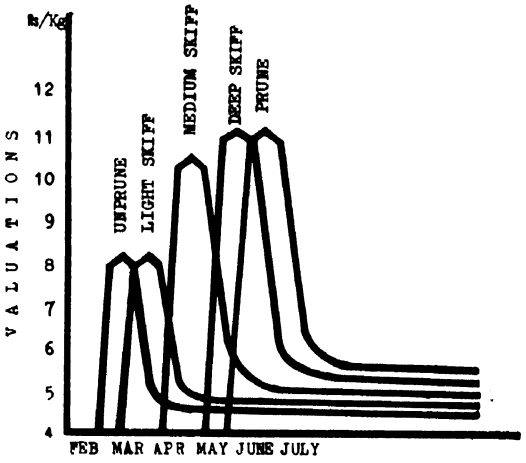
Increased yield can most certainly be obtained by adopting longer pruning cycles. But unfortunately longer pruning cycles where lighter forms of skiff are adopted resulted in a reduction of quality. So unless the increased yield obtained from longer pruning cycles more than compensates for any drop in unit price, longer pruning cycles may not pay.

With longer pruning cycles a mixing of flushes takes place on the estate due to the variation of time of flushing according to the different types of skiffing and clean pruning.

The lighter the skiff, the earlier is the first and second flush. From unpruned tea the quality teas are produced in late February early March whilst from three year Tocklai pruning cycle, quality teas are produced from late April to late June/early July, From pruned estates quality teas are produced from mid May to late June/early July.

Figure III shows how different types of skiffing and pruning affects the quality in the early part of the season. The lighter the skiff the lower is the quality and the earlier is the quality flush. Again in longer pruning cycles where different forms of skiff along with prune are introduced, there is bound to be mixing of flushes on estates. In the case of a three year pruning cycle of prune, deep skiff and

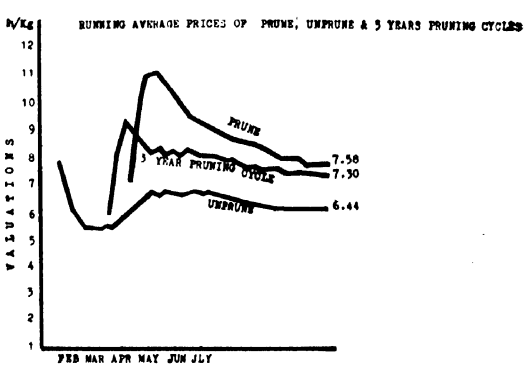
FIG.III



medium skiff the difference in quality between prune and deep skiff is practically nil but there is a difference between prune and medium skiff; the medium skiff being inferior. In a three year cycle of P-MS-DS the medium skiff areas flush first then deep skiff, followed very closely by prune. As a result, leaf from all these three types of pruning and skiffing is mixed, resulting in dilution of true N. E. Indian high quality which causes the valuation of the high quality early season teas to be reduced.

Figure IV shows the running average prices obtained by estates known to be on prune, unprune (about 70%) and on three year pruning cycles (with prune, medium skiff and deep skiff).

FIG. IV



The average price of the tea from the prune bushes is definitely superior to that from the three year pruning cycle or unpruned bushes particularly during the second flush. The more valuable second flush teas from prune seems to cause a higher average price over the year than the three year pruning cycle. In unprune, however there is little or no real quality in second flush period. The highest priced tea produced from unpruned is from the first flush but it is less valuable than the second flush tea of three year pruning cycle or of prune. From Fig. IV it can be seen that at the end of the year the unpruned tea average out at about a rupee less than the pruned or the three year pruning cycle. It is of interest to note that a few commercial estates who kept about 50% or more unpruned this season dropped in their average price by about Rs. 1.10 to 0.85 paise per kg.

Results of our experiments in small scale with clone and *jat* also confirm the deterioration of value of the made tea due to leaving the bushes unpruned or by adopting lighter forms of skiff.

MANUFACTURING ADVISORY

Withering : Withering troughs are becoming more and more popular and very often we are asked as to what length should be the withering trough. It is preferable to confine the length of the withering trough to not more than 26 m (85') with a width of 183 cm - 213 cm (6'-7'). In troughs longer than 26 m it becomes difficult to have even air and temperature distribution. Whilst ordering fans for withering trough the following points should be borne in mind. For every 37 kg (1 md) of leaf 750 c. f. m. of air is required in withering troughs and 37 kg of fresh leaf spread at 20.32 cm (8") thick occupies 1.30 sq. m (14 sq ft). There are very many troughs with too low a fan capacity giving thereby a very slow rate of evaporation, resulting in insufficient wither being obtained.

C. T. C. Roller Speeds : C. T. C. roller speeds should be confined between 700—650 R. P. M. for the high speed and 70-65 R. P. M. for the slow speed keeping the ratio at 1 :10. With higher speeds the leaf does not get processed properly and also there is a tendency for the leaf falling into the C. T. C. rollers to fly off.

Fermentation : Fermentation in deep layers is now coming into practice in tea industry. With C. T. C. manufacture, especially with inadequate wither, a considerable amount of balling is experienced in leaf fermented in deep layers. It is advisable to pass the fermenting leaf through a small Paddle Ball Breaker or a vibratory screen before putting it into the drier. The ideal would be to fit a vibratory screen on top of the drier feed. This will not only reduce balling but also result in improved drying.

Drying : There seem to be a belief that better drying is obtained if the air to the drying stove is taken from inside the factory. This is wrong. There should be sufficient opening to the stove to suck in enough fresh air from outside the factory. This not only improves drying considerably but also increases the drier output. By simply removing the wall at the back of the drier stoves the output in one factory went up from 80 kg to 130 kg per hour per drier. Allowing fresh air to the stoves or heaters is no less important than having sufficient opening on the exhaust side to allow exhaust air to leave the drying room freely. Both these factors affect the output as well as quality of the tea appreciably.

TESTING OF COMMERCIAL PRODUCTS

Conveyor belting : 'Renef' food quality conveyor belting supplied by J. H. Fenner & Co. (I) Ltd., Calcutta was found suitable for use in tea factories.

Tea chest lining : Polythene extrusion laminated kraft paper for lining of tea chest supplied by Ganeriwala & Sons, Calcutta, was found suitable for use for the purpose.

Cleaning agents : The detergent in powder form made by Kusum Products, Calcutta, was tested and found suitable for use in tea factories.

TEA TASTING AND ESTATE VISITS

Tea Tasting : During the season 3,370 experimental samples from Tocklai, 11,360 samples from estates for advising on manufacture, and 3,442 clonal samples from estates were tasted. Besides this numerous samples were also tasted during visits to the factories.

There has been a considerable increase in the number of samples brought to Tocklai for advising on manufacture. The number of estates seeking advice on manufacturing problem also increased considerably. Nine group tastings were held during the year, and more and more estates are attending these sessions. Estates are more conscious of quality than at any other time in recent years and a definite general improvement in the standard of manufacture has been made in last two years. It will not be too much to expect a still better standard next season.

Estate Visits : 114 factory visits were made for advising on manufacture by the Manufacturing Adviser & Tea Taster. Although the total demand for visits were much more, a number of requests for visits simply could not be physically complied with.

Lectures : Two lecture courses on Factory Management together with demonstrations were conducted by the Manufacturing Adviser & Tea Taster in co-operation with the Engineering Development Department.

Meetings : The Manufacturing Adviser & Tea Taster attended six Area Scientific Committee Meetings.

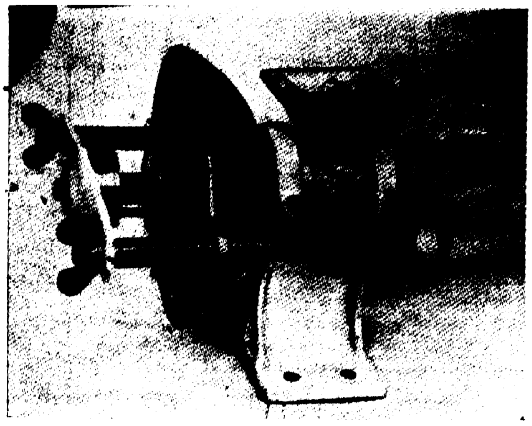
The Engineering Development Department

RESEARCH AND EXPERIMENT

ROLLING

Continuous Green Leaf Processing Machines

1. Disc Type Continuous Roller : The 122 cm (48") Disc Roller installed at Kharikatia T. E. early in the year, could not be operated fully due to shortage of sifters in the early part of the season and thereafter because the estate switched over to C. T. C. manufacture.



Mini Disc Roller

Arrangements were, therefore made to shift the roller to a factory on pure orthodox manufacture.

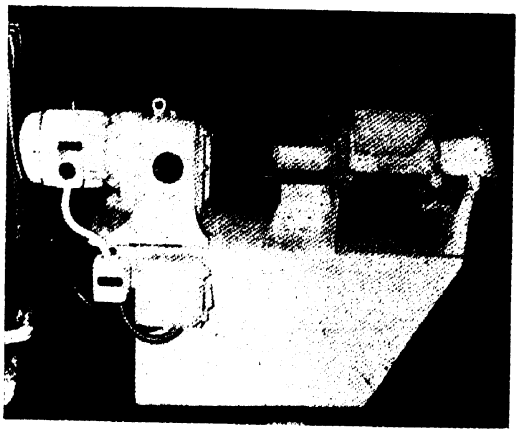
Nahorani T. E. in the North Bank volunteered, and the roller was installed there at the end of September. The Disc Roller was, therefore, in operation only at the end of the season. The few samples manufactured were tasted and from the results it appears that one pass through the Disc Roller together with a roll in an orthodox roller produced good orthodox teas independent of the sequence in which they are used.

It has been decided to have a commercial prototype version of the machine made by the Association's licensees, Port Engineering Co., early next season.

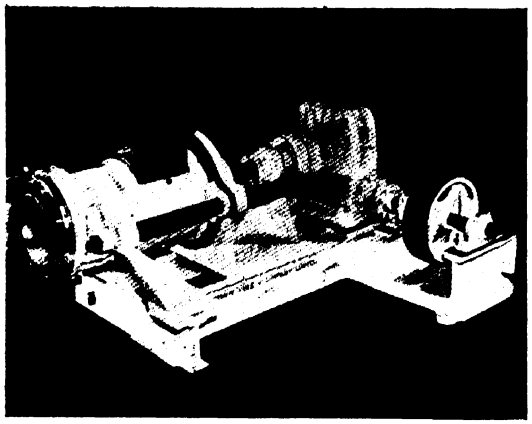
II. Continuous Tea Roller : Vertical Type:

To improve the throughput of the vertical roller the feedworm of 15 cm (6") pitch and the feed cylinder of 20 cm (8") diameter were replaced by a feedworm of 20 cm (8") pitch and a feed cylinder of 30.5 cm (12") diameter. Thus modified, the roller was in operation during the year. From reports it appears that double legg-cut tea rolled once in this roller and then once in an orthodox roller is satisfactory. But the commercial possibilities of this roller are very limited indeed.

III. Barbora Leaf Conditioner : The 8" Barbora Leaf Conditioner was in operation in the Tocklai Pilot Factory throughout the season. Trials with different types of fitments on the cone were also carried out and from the results seen so far, a spiral



Barbora Leaf Conditioner



Barbora Leaf Conditioner

battened cone shows some promise. An analysis of the results of the various trials with this machine, given below, shows that while there is no appreciable difference in valuation of C. T. C. teas conditioned by the Leaf Conditioner; on pure rotorvane manufacture, the rotorvane produces fuller teas compared to those from pure leaf conditioner processing. The results are shown below :

C. T. C. Manufacture

Method of manufacture	No. of Tests	Average Valuation	Remarks
1 pass through 8" Leaf Conditioner fitted with a helical battened cone followed by 2 cuts CTC	34	Rs. 5.50	Leaf conditio: c /CTC Teas pre - ferred on 1(occasions.
1 pass through 6" Rotorvane followed by 2 cuts CTC	34	Rs. 5.66	
1 pass through 8" Leaf Conditioner fitted with spiral battened-cone followed by 2 cuts CTC	32	Rs. 5.49	Leaf conditione /CTC teas pre fered on 1 occasion:
1 pass through 6" Rotorvane followed by 2 cuts CTC	32	Rs. 5.43	
2 passes through 8" Leaf Conditioner fitted with-spiral battened cone	6	Rs. 4.74	Leaf conditione samples wer preferred on occasions only
2 passes through 6" Rotorvane with cone	6	Rs. 5.20	

An experiment was conducted to find out if harder pressure in the Leaf Conditioner was better than normal pressure by adjusting the sleeve in the barrel. Results indicated that on 12 occasions out of 25, leaf processed under hard pressure in the Conditioner were preferable to those processed under lower pressure. The average valuation in Rs./kg indicated that the difference in valuation was Rs. 0.07 only. Hard pressure teas obtained Rs. 5.38 average valuation as against low pressure teas with an average of Rs. 5.45. The Association has since granted its manufacturing licence to Port Engineering Works.

IV. Tocklai Continuous Roller : The 51 cm (20") TCR Mark II was operated from time to time at Heeleakah Factory in competition with orthodox rollers. During the early part of the season the experiment could not be continuously carried out due to shortage of green leaf sifters; but later on, one sifter was secured on loan from Britannia Engineering Co. The trial was carried on continuously thereafter and on those occasions when weather conditions were favourable and the leaf was fully withered, the teas manufactured in this roller had more tips in comparison with the normal Heeleakah samples. But under general conditions, the normal Heeleakah teas were fuller, harder and of better make.

When withers were good i. e. harder than 65%, the teas from T. C. R. were definitely superior to those from normal orthodox manufacture. Hence it appears that this machine is capable of giving optimum performance only with fine, well withered leaf and if these conditions are not met the full potential of this roller cannot be realised.

One of the principal reasons why the T. C. R. does not operate satisfactorily with leaf of indifferent wither is that while in orthodox rollers there are adequate chances of expressing the extra juice from the leaf which is drained away from the leaf mass, thereby imparting to it a degree of "mechanical wither" as opposed to "physical wither", the T. C. R. does not cater for draining of juice and there is no chance for "mechanical wither" to take place. This factor is responsible for the inadequate rolling action of the T. C. R. with leaf of indifferent wither.

In any continuous roller, if the leaf does not have adequate wither, the excessive juice behaves like a lubricant under pressure thereby separating the leaf particles from one another and preventing leaf against leaf action, which is the basis of good leaf processing in orthodox manufacture.

FERMENTATION.

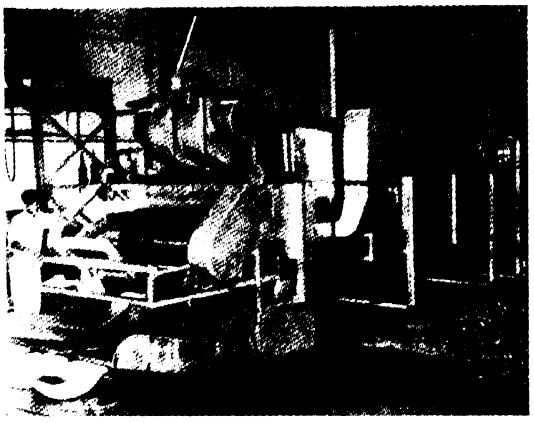
Tocklai Continuous Fermenting Machine : The 5' Prototype Continuous Fermenting Machine was completely overhauled at Tocklai early in the year and some modifications were incorporated in it to facilitate cleaner conditions in discharging leaf and to render the machine equally adaptable for both orthodox and CTC teas. Early in February the machine was installed at Sycotta Factory. The 5 ton air-conditioner purchased for use with the earlier Fermenting-cum-Drying Machine was also tried out in the recirculatory ducting of the new machine to study the effects of lower temperature on fermenting leaf in deep layers. But the air-conditioner could not cope with the amount of additional heat brought into the machine by the mass of leaf from the processing machines on top of the amount of heat generated during fermentation. It was therefore operated without the air-conditioner for most part of the last manufacturing season.

Prototype Fermenting Cum Drying Machine

One great difficulty, which could not be solved was the sources of leaf put through the machine, which of estate necessity were variable according to pruning cycle, clone and *jat*. This made comparative tasting and valuations difficult and as the Manager sympathetically said, "This means there is really no possible check (for rigid comparisons)". Hence the comparisons were only possible batch-wise and not between batches.

The Fermenting Machine was tried in conjunction with orthodox type of manufacture during the early part of the season. Fine and coarse leaf, after two 30 mts orthodox rolls, was fed at a spread of 8" thick. The time cycle was latterly kept at 1 hr. 20 mts. after initial trials at 1 hr. 38 mts. At this timing, leaf was found to be evenly and adequately fermented. The capacity of this 5' prototype has been found to be 500 kg/hr for orthodox type of leaf. The pressure inside the chamber was found to be approximately 0.02" W. G. which indicates that for orthodox type of leaf, the thickness of spread could easily be increased without imposing too much load on the recirculatory fans. The Tocklai Tea Taster's preferences on the orthodox type teas fermented in the continuous machine as compared to Sycotta normal tray fermentation are shown below. The Taster remarked "CFM samples were over-fermented, although bright they lost hardness. They will do well slightly shorter fermentation". From the above remark and from the general trend of results obtained from the C. F. M. it is apparent that this method of fermentation hastens the rate of oxidation of orthodox teas.

From May onwards the factory switched over to pure C. T. C. manufactre and the machine was then operated continuously in conjunction with Rotorvane/ C. T. C. manufacture until the end of the season.



New Tocklai Continuous Fermenting Machine

A summary of the trend of results obtained from this machine is given below : The time cycle used was between 45 mts and 1 hr. 10 mts. depending upon the weather and wither, the average being 50 mts. At this timing and 6" thickness of spread, the capacity of the machine for C. T. C. tea is 850 lb./hr. From the tasting results it appears that C. T. C. tea fermented at a thickness of 6" or below are better than those fermented deeper. The temperatures of the fermented leaf at discharge, were found to be upto 115°F against the maximum of 98°F of the normal tray fermented teas. The break-down of the number of samples on the basis of temperature at discharge shows that high temperatures of fermenting leaf upto about 110°F do not have any detrimental effect on the tea; rather, the percentage of number of times C. F. M samples were preferred is higher if the fermenting leaf temperatures are not allowed to rise above 110°F.

Summary of trials with C. F. M. on Orthodox Teas

Spread	Duration	% Wither	Actual operating hrs.	No. sets of comparative samples	No. times C. F. M. teas preferred by tea taster.
8"	1 hr 38 mts.	68	3 hrs 35 mts	5	1
8"	1 hr 20 mts	62—65	13 hrs 05 mts	18	8

Summary of Fermentation tests with Rotorvane/CTC processed leaf in prototype 5' C. F. M. at Sycotta Tea Estate.

Thickness of spread inches	Rate of injection of oxygen lit/ /min	Average wither %	Fermentation time minutes	Actual operating hrs. mts.	No. of sets of comparative samples drawn	No. of samples from C. F. M. preferred by Tocklai Taster
8	5	78	45	10	1	0
7	5	76—80	15—38	15—38	12	7
7	3	74—78	55—60	48—53	39	21
7	2	76—78	55	33—33	28	18
7	5	75—80	45	8—25	6	4
7	2	73—78	45—60	74—24	53	23
6	5	74—100	45—70	307—10	187	118
6	4	76—95	55—70	150—40	92	52
6	3	75—85	50—70	121—42	78	45
6	2	74—76	45—55	31—10	23	17
6	5	73—80	45—49	8—05	7	5
6	8 + air	76	51	2—10	1	0
6	5 + air	76—78	49—51	10—55	9	3
6	Air only	76—78	49—51	12—05	14	8
				826—00	550	321 (58.4%)
	At or below 6" spread total :			643—57	411	248 (60.2%)

Breakdown of CFM samples tasted on the basis of maximum temperature at discharge.

Range of discharge temperatures.	No. of sets of comparative samples	No. of CFM samples preferred	Percentage of No. of times CFM samples preferred
Below or at 100°F	280	152	54.3
Between 101°F and 105°F	184	116	63.0
Between 106°F and 110°F	73	45	61.7
Above 110°F	13	8	61.5

Towards the end of the season, leaf temperature profiles along the length of the tray run in different layers of leaf in the bed were taken by the Plant Physiologist using his automatic temperature recorder. Samples of fermented leaf were also collected at the same time from these layers and dried under identical conditions at Tocklai for comparative evaluation. Tasting results showed that the sample from the layer where the temperature profile throughout the run was most uniform, and where the average and maximum temperatures were highest, was the best. It has therefore been decided to experiment next season with differeat air flow patterns in the recirculatory air stream to sort out the problem of efficient and economical way of maintaining an even temperature in the entire bulk of fermenting leaf inside the chamber.

The capacity of this prototype machine for CTC processed leaf falls short by a third of the average

output of a 15" rotorvane. The commercial machine, therefore, would be so made that it copes with the output of one bank of Rotorvane/CTCs at the average thickness of spread of 6". The capacity of the machine can then be made flexible enough to cope with greater or smaller amounts of leaf depending upon the day to day requirement of the factory. In order to achieve a throughput of approximately 1500 kg of fermented leaf per hour for a prototype commercial version of this machine, general arrangement drawings are being prepared at Tocklai.

The oxygen requirement of the machine is found to be very small indeed. A normal oxygen cylinder, containing 6,000 litres of oxygen costing approximately Rs. 30/- in the Tea Districts of N. E. India, should last for 20 hours of actual operation at optimum capacity. The cost of oxygen is approximately $\frac{1}{3}$rd of a paise per kg, or Rs. 3/- per 1000 kg of made tea.

MOISTURE CONTENT OF TEA

A capacitance type instant moisture meter for made tea was built during the year employing a capacitance bridge. Efforts were made to account for the additional parameter i. e. the weight of a definite volume of tea in the instrument itself to enable the moisture content of a tea sample to be read directly on a dial. Preliminary trials of the instrument showed that further modifications and adjustment will be necessary.

PLUCKING AID

The manual plucking aid was in operation from time to time during the season at Borbhetta. The project of getting the components made in light plastic material reported last year could not be taken up for lack of sufficient interest anongst well-known plastic manufacturers contacted so far.

GENERAL

The Senior Research Engineer attended two meetings of the Engineering Sub-Committee in Calcutta and a meeting of the Area Scientific Committee at Tingrai. On two occasions he visited the Britannia Engineering Co. in connection with Tocklai Machinery under manufacture. Advisory visits were paid by the Senior Research Engineer to fourteen tea factories in Assam and twelve tea factories in Cachar. In addition routine visits were paid to Sycotta, Kharikatia and Heeleakah T. Es. in connection with operation and further development of prototype machinery installed in these estates. He was a member of the three man team of Tocklai Officers visiting Kenya, Uganda and Malawi from 14th January to 25th February. A report on this visit was prepared and distributed to the members of the Tea Research Association. He was on study tour to U. K. for six months from mid September '69 to mid March, 1970. A detailed report on this visit is being prepared by him.

The second Research Engineer was in charge of the department during the absence of the Senior Research Engineer. He lectured in the two courses on Factory Management at Tocklai and attended the Annual General Meeting of the T. R. A. at Calcutta. He had also the routine visits to Sycotta, Kharikatia and Heeleakah T. Es in connection with the trials of the machinery installed in these estates.

Statistics Department

Help to Other Departments

During the year, the Department extended intensive co-operation and help in solving more than thirty statistical problems encountered by research workers of different Departments of the Station in relation to experiments with agriculture, biochemistry, entomology, mycology, manufacturing and tasting of tea samples. A number of long-term experiments were analysed on the electronic computer at the Indian Institut of eTechnology, Kanpur & consequently a number of FORTRAN programmes were written during the year.

Satistical Study of the Chemistry of Tea

It has been shown that regardless of tasters and methods of manufacture, 'quality' of made tea was generally found to depend mainly on 'briskness', and the 'cash valuation' depended mainly on quality and/or briskness ("Two and A Bud", 1968, Vol. 15, No. 1, pages 24-30). Hence, the study was first confined to the influence of biochemical constituents on briskness, quality and cash valuations and their effects on these, both of C. T. C. and orthodox teas. The results are summarised below.

Initially the study was started with about 154,000 figures consisting of 7 clones and a *jat*, 33 and 34 biochemical constituents in their curvature forms, of C. T. C. and orthodox teas respectively, 6 dates, 4 tasters, 5 made tea liquor characters, cash valuation, and 2 methods of manufacture. The computations of the large mass of data were carried out on the IBM 7044 electronic computer at the Indian Institute of Technology, Kanpur. After preliminary investigation, from the biochemical and statistical points of view, 15 constituents of each of C. T. C. and orthodox teas were excluded from the study. Hence, the remaining 18 and 19 biochemical constituents of C. T. C. and orthodox teas respectively were considered together in the analysis to find out their relative contributions to the briskness, quality and cash valuation, both of C. T. C. and orthodox teas, and also their effects on these liquor characters and the cash valuation. Analyses were carried out separately for each taster and for each method of manufacture.

Amongst the significant biochemical constituents for individual tasters which together contributed, in general, 74 p. c. to 96 p. c. towards briskness, quality and cash valuations of C. T. C. teas, nine constituents for each of briskness and cash valuation, and 11 constituents for quality were found to be common to more than two tasters and also two tasters showing more or less similar effect of the constituents. It was also found that in general for the majority of tasters, the joint contributions of these common constituents towards briskness, quality and cash valuations were more than 70 per cent.

These results, therefore, suggest that briskness, quality and cash valuations of C. T. C. manufactured teas are almost fully influenced by the significant common constituents.

Further, it was observed that five constituents, total oxygen uptake and theogallin (TG) of unprocessed tea shoots, and theaflavins (TF), (−) – epicatechin gallate, and theogallin (TG) of made tea were found to affect both the liquor characters and the cash valuations of C. T. C. teas. Not only that, these five common constituents, affecting each of briskness, quality and cash valuations, together contributed, in general, about 60 p. c. towards each liquor character and the cash valuation of C. T. C. teas.

These results, therefore, suggest that total oxygen uptake and TG of unprocessed tea shoots, and TF, ECG and TG of made tea are the main controlling biochemical constituents of C. T. C. manufactured teas.

Similarly, for orthodox teas also there were number of common biochemical constituents which were found to affect both the liquor characters and the cash valuations. Further, it was also found that, in general, these common constituents, viz., enzyme

activity, total oxygen uptake and ECG of unprocessed tea shoots, and TF, ECG, TG and water soluble solids (other than cash TF, TR, EGC, EGCG, EGC, TG, caffeine nitrogen and aminoacid nitrogen of made tea) of made tea, jointly contributed about 55 p. c. towards briskness, quality and cash valuations of orthodox manufactured teas.

Therefore, from these results it can be said that enzyme activity, total oxygen uptake and ECG of unprocessed tea shoots, and TF, ECG, TG and water soluble solids (other than the constituents mentioned above) of made tea are the major contributing constituents of each of briskness, quality and of cash valuation of orthodox manufactured teas.

By comparing the results of C. T. C. and orthodox teas it was noticed that four biochemical constituents, total oxygen uptake of unprocessed tea shoots, and TF, ECG and TG of made tea were found to affect both the liquor characters and also the cash valuation, both of C. T. C. and orthodox teas. Not only that, it was also found that, in general, these four constituents together contributed about 50 p. c. towards each of briskness, quality and cash valuations, both of C. T. C. and orthodox teas.

These results, therefore, suggest that regardless of tasters and methods of manufacture, total oxygen uptake of unprocessed tea shoots, and TF, ECG and TG of made tea are the main guiding constituents of a desirable North East Indian plains tea.

For different tasters, the types of relationship between the significant biochemical constituents and the tasters' marks on each of briskness, quality and cash valuations, both of C. T. C. and orthodox teas, were found to vary from taster to taster. These variations, however, might be attributed to the taster to taster variations in their degree of preference, and likes and dislikes of a particular chemical constituents. However, the effects of the most important biochemical constituents on each of briskness, quality and cash valuations were generally found to be more or less same for all the tasters. Thus, the effects of total oxygen uptake and TF on each of briskness, quality and cash valuations, both of C. T. C. and orthodox teas, were generally found to be beneficial, i.e., tasters' marks on briskness, quality and cash valuations, both for C. T. C. and orthodox manufactured teas, generally increased with the increase in total oxygen uptake of unprocessed tea shoots and TF concentration of made tea; whereas the effects of ECG and TG of made tea were generally found to be beneficial only beyond certain concentrations.

Further, it was noticed that some of the significant biochemical constituents which together had generally minor contributions towards briskness, quality and cash valuations of C. T. C. and orthodox teas, and also the number of significant constituents were found to vary from taster to taster. These variations amongst tasters might be attributed to the variation in sensitiveness of tasters' palates, and to the taster to taster variation in their policy of assessing the made teas according to the consumer's market requirement. However, for the major part of the variations in each of briskness, quality and cash valuations, both of C. T. C. and orthodox teas, generally the tasters were in agreement.

It was also noticed that some of the significant biochemical constituents which together had generally minor contributions towards the liquor characters and the cash valuations, and also the number of significant constituents varied between the two methods of manufacture i.e., between C. T. C. and orthodox methods. These differences seem to be reasonable because of the differences between the two manufacturing methods. But, major part of the variations in each of briskness, quality and cash valuations was contributed by the significant constituents which were found to be common between the two methods of manufacture.

It is interesting to note that the results discussed here based on biochemical constituents of the tasted teas, both for C. T. C. and orthodox teas, also support the previous findings i.e., the assessment of quality of North East Indian plains made tea is based primarily on briskness and, to a minor extent, on other liquor character (s) which varies from taster to taster depending on the requirement of the consumer's market or on their personal preferences, and the

assessment of cash valuation is based mainly on quality and/or briskness and, to a minor extent, on other liquor character (s) which varies from taster to taster ("Two and A Bud", 1968, Vol. 15, No. 1, pages 24-30).

From all the results discussed here, it can be concluded that regardless of tasters and methods of manufacture, four biochemical constituents, total oxygen uptake of unprocessed tea shoots, and TF, ECG and TG of made tea are the main guiding constituents of a desirable North East Indian plains tea. But, for more precise guidance, for C. T. C. method of manufacture one more constituent i.e., TG of unprocessed tea shoots, and for orthodox method three more constituents i. e., enzyme activity and ECG of unprocessed tea shoots, and water soluble solids (other than ash, TF, TR, EGC, EGCG, ECG, TG, caffeine nitrogen and aminoacid nitrogen) of made tea should be considered.

This study leads to a step forward in obtaining a quantitative basis for the assessment of made teas of North East Indian plains. These results are expected to be of tremendous use to those who are engaged in clonal selection, plant breeding and manufacturing machinery development.

Survey of Shade Trees

To study the rate of growth with age of different species of shade trees under the conditions prevailing in the six circles, Nowgong, Jorhat, Nazira, Dibrugarh, Naharkatia and Panitola of the Assam valley, girths of shade trees were measured at 122 cm height from the ground level and spread of foliar canopy was measured as the mean radious from the trunk during the rainy season (1st round : July to September, 1965) and the cold season (2nd round : January to March, 1966) on two sub-samples of shade trees from each of the twenty selected tea estates in the above six circles. From this survey it was found that in the above six circles the area under tea was shaded mainly by the three species, *Albizzia odoratissima, Albizzia procera* and *Albizzia chinensis* ("Two and A Bud", 1967, Vol. 14, No. 3, pages 125-128). Hence, the study on the rate of growth had been confined on these species only.

The estimates on the rate of increase in girth and spread of foliar canopy with age obtained from the two rounds were found to be the same. Hence, combined estimates were obtained from the two rounds and the results are summarised below.

Regardless of circles and species of shade trees, the rate of increase in growth of shade trees in terms of girth and spread of foliar canopy was found to decrease gradually with the age. But, these rates were found to vary from species to species within a circle and also within species between circles. Thus, *Albizzia chinensis* was found to grow better than the other two species in Nowgong, Nazira, Dibrugarh, Naharkatia and Panitola circles; whereas in the Jorhat circle all the three species of shade trees were found to grow equally well. Further, amongst the six circles *Albizzia chinensis* was found to grow best in the Nowgong circle.

Sampling and Experimental Technique

(a) To maximise the efficiency and minimise the cost of experimentation, a study from one uniformity trial data in the Assam valley, on the adjustment of post-treatment yields by the ancillary variables, viz., pretreatment yields up to June, July to August, September to December, whole season's crop and the pretreatment pruning weights, indicated that amongst the ancillary variables pretreatment yield from September to December was found to be most efficient when the experiment continued for one or two or three years. The study is, however, being continued on large number of experiments and on more number of years to confirm the finding.

(b) In order to evolve a suitable sampling technique at the field and to develope a suitable experimental technique for miniature manufacture and taste testing of experimental samples, seven pilot experiments were conducted during the year to provide guide lines.

The analyses of the data showed that considerable amount of variations were found to creep in during miniature manufacture and tasting of experimental samples. This indicates that in all probability, the estimates of treatment differences in taste testing experiments are being camouflaged by these varia-

tions. The investigations will, however, be continued to suggest, if possible, some statistical remedy to the problems.

Long-term Survey-Experiments on Defoliation

The data collected during the year 1969 from the long-term survey-experiments on defoliation in the Dooars were analysed.

During 1968/69 cold weather season the two main plot treatments, Prune-Deep Skiff and Prune-Deep Skiff-Medium Skiff, received prune and medium skiff respectively.

The yields in all the experimental plots were lower compared to last year due to strike in the Dooars during 1969.

The red spider infestation was generally found to be low in all the control (no defoliation and no chemical spraying) plots, and in the treated plots it was controlled satisfactorily. The yield of defoliated plots was, however, found to be significantly lower than the undefoliated plots which received either the chemical prophylactic or chemical palliative spraying or both with Tedion and the loss was found to be more than double (15 p.c. as against 7 p.c. last year) compared to last year over the undefoliated chemical prophylactic sprayed plots. As in 1967 and 1968 (Tocklai Annual Scientific Rep., 1968-69, pages 102-106) this loss may be attributed to the detrimental effect of the continuous defoliation.

The experiment will be continued to study the objectives outlined in the previous year's report (Tocklai Annual Scientific Rep., 1968-69, pages 102-106).

Touring and Advisory

The Statistician and two members of the Department visited the Indian Institute of Technology, Kanpur thrice and one member visited once in connection with the statistical analyses of data from long-term and complex experiments on the IBM 7044 electronic computer. The Statistician also visited the Indian Statistical Institute, Calcutta, IBM, ICL, Continental Commercial Company, Singer Sewing Machine Company and Blue Star Limited offices in Calcutta during the year. Three members of the Department visited Bokahola T. E. weekly in connection with the uniformity trial there. Mr. R. M. Sanyal, Scientific Assistant, attended a course on programming and applications of electronic computer at the Indian Statistical Institute, Calcutta from 27. 10. 69 to 24. 1. 70.

Library and Publication Department

LIBRARY

General

The Library added 5 new Scientific Journals to the subscription list and discontinued 2 journals. Subscription rates to several foreign Scientific Journals have again increased this year. The Library subscribes to 123 Scientific journals.

Loan Service

A total of 136 publications were issued to the different departments of the Station and 996 publications were consulted in the Library during the year.

21 Scholars from Assam Agricultural University, 10 Scientists from R. R. L., Jorhat and eight Tocklai Trainees in addition to Tocklai Scientific Staff regularly attended the Library.

Book Binding

A total of 472 volumes were bound and more volumes of old and new journals will be bound in the next financial year. It is hoped that rebinding of old volumes will be completed by 1971.

Library Statistics

Books added during the year	—	99
Periodicals & Journals	—	2900
Pamphlets	—	636
Photocopies	—	22
Reprints	—	668

PUBLICATIONS

The Publication Section was kept extra busy due to publication of several Soil Survey Reports, Miscellaneous Tour Reports and a special edition of Two & A Bud.

It has been decided not to publish the December 1969 and March 1970 issue of Two & A Bud to enable the Tocklai Scientists to revise the Tea Encyclopaedia Serials which were mostly out of date.

The following publications were issued during the year :-

(1) Two & A Bud :

Vol. 16, Nos. 1, 2, 3 and a special edition 'Drainage Report'.

(2) Tocklai Occasional Scientific Papers :

Soil Survey 1967/68 No. 5, Results for Dibrugarh and Doom Dooma areas.

Soil Survey 1967/68 No. 6, Results for Nazira and Golaghat areas.

Soil Survey 1967/68 No. 7, Results for Nowgaon District.

(3) Miscellaneous Reports;

Annual Scientific Report for 1968/69

Report on a visit to Malawi, Kenya and Uganda. By D. N. Barbora (restricted circulation)

Report on a visit to Malawi, Kenya and Uganda By S. K. Dutta (restricted circulation)

Engineering Development Department Quarterly reports. (restricted circulation)

A view of the Library Reading Room

(4) Tea Encyclopaedia Serials

In January 1970 the entire Tea Encyclopaedia was thoroughly checked by the 'Tea Encyclopaedia Revision Committee' of Tocklai. The Committee found eighty one Serials out of date and they were

withdrawn from Encyclopaedia. Fifty Serials are being revised or amended and fourteen new serials are being published gradually. In this year the following were published :

Serial No. 43/4 Infilling & Treatment of Infills.

Serial No. 168/1 The use of Herbicides for the control of Mikania.

Serial No. 110/3 Compatibility of Insecticides, Acaricides and Fungicides commonly used in tea.

Serial No. 183 Some major pests of shade trees and their control.

Serial No. 17/5 Installation of Meteorological Instruments and Meteorological Observations.

Serial No. 157/1 Metric System- Useful Tables on Planting distances.

Serial No. 53/3 Amendment - Amendment slip for serial No. 53/3 (Medium Pruning).

Serial No. 8/3 Amendment - Amendment slip for Serial No. 8/3 (Black Rot).

Serial No. 61/3 Amendment - Amendment Slip for Serial No. 61/3 (Red Rust).

J. N. Sharma
Librarian and Publication
In-charge.

Appendix-A.

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
by
THE ADVISORY DEPARTMENT
South Bank, Assam

Project	Site	Index	Year of starting
Rehabilitation of land	Sangsua	AS 45	1963
	Duklingia	AS 48	1964
	Ghillidary	AS 49	1964
	Hansara	AS 50	1964
N. P. K. Manuring	Murmuria	AS 11	1956
	Khoomtaie	AS 29	1959
	Katonibari	AS 44	1963
	Hunwal	AS 51	1964
	Dirok	AS 63	1965
	Ghillidary	AS 88	1968
	Hunwal	AS 92	March, 1969
	Doomdooma Tea, Co	AS 95A	1969
	,,	AS 95B	1969
	Haroochari	AS 98	Feb., 1970
Nitrogenous fertiliser	Sycotta	AS 56	1964
	Sagmootea	AS 62	1965
	Joonktollee	AS 64	1966
	Nahorhabi	AS 65	1966
	Furkating	AS 69	1966
	Halmirah	AS 71	1966
	Cinnamara	AS 77*	1966
	Meleng	AS 78*	1966
	Borsillah	AS 79*	1966
	Joonktollee	AS 82	1967
	Gabroo Purbut	AS 83	1967
Purning	Cinnamara	AS 12	1957
	Duklingia	AS 13	1958
	Dufflating	AS 84	1967
	Nahorhabi	AS 90	1968
	Margherita	AS 97	1969
Cultivation & Weed Control	Cinnamara	Short	1965
	Katonibari	Term	1969
	Dessoie	Trials	1969
	Sotai	—	1968

*Effect of nitrogen with and without liming.

Project	Site	Index	Year of starting
Irrigation	Amluckie	AS 52	1963
	Borahi	AS 67	1966
	Gorunga	AS 68	1966
	Gabroo Purbut	AS 70	1966
	Dejoo Valley	AS 72	1966
	Dejoo Valley	AS 73	1966
Jat and Clonal trial	Tyroon	AS 89	1968
	Tyroon	AS 89 & AS96	1969

NORTH BANK, ASSAM

Project	Site	Index	Year of starting
Rehabilitation of land	Tarajuli	AN 46	1964
	Deckiajuli	AN 47	1964
N. P. K. Manuring	Borjuli	AN 85	1968
	Dekorai	AN 87	1968
	Ananda	AN 93	1969
Nitrogenous fertiliser	Halem	AN 3	1933
	Nahorani	AN 59	1964
	Gingia	AN 80*	1966
	Hatigar	AN 91	Jan., 1969
	Ananda	AN 94	1969
Purning	Phulbari	AN 58	1964
	Ghoirallie	AN 60	1965
	Kolony	AN 76	1966
Irrigation	Balipara	AN 55	1963
	Sessa	AN 61	1965
	Durrung	AN 74	1966
	Mazbet	AN 75	1966
Cultivation and Weed Control	Halem	AN 15	1958
	Halem	AN 31	1960

* Effect of nitrogen with and without liming.

CACHAR., ASSAM.

Project	Site	Index	Year of starting
Rehabilitation of land	Koomber	C 25	1964
N. P. K. Manuring	Isa Bheel	C 26	1966
	Hattikhira	C 27	1966
	Longai	C 28	1966
	Silcoorie	C 32	1967
Nitrogenous fertiliser	Pallorbund	C 29	1966
	Dewan	C 30	1966
Pruning	Pallorbund	C 33	1967
	Dewan	C 34	1967
	Derby	C 35	1968
Irrigation	Roopacherra	C 31	1966
Shade and Manuring	Koomber	C 36	1968
Soil climatological survey	Coombergram	C 20	1962

DOOARS AND TERAI, WEST BENGAL

Project	Site	Index	Year of starting
Rehabilitation of land	Bhogotpore	D 27	1964
	Grassmore	D 28	1964
N. P. K. Manuring	Kalchini	D 1	1954
	Nedam	D 30	1963
Nitrogenous Fertilizer	Baradighi	D 33	1966
	*Bhatpara	—	1968
	*Gopalpur	—	1968
	*Dem Dima	—	1968
	*Chengmari	—	1968
Pruning	Chuapara	D 2	1955
	Baradighi	D 4	1959
	Sam Sing	D 34	1966
Irrigation	Gopalpur	D 35	1966
	Ranicherra	D 36	1968
	Rajabhat	D 32	1968
	Tirrihannah	TR 1	1968

Project	Site	Index	Year of starting
Cultivation & Weed Control	Chuapara	D 42	1970
	*Chuapara	D 10	1957
Shade & Manuring	Nya Sylee	D 24	1962
Shade	Nya Sylee	D 9	1958
Infilling	Kartick	—	1969
	Jainti	—	1969
	Fagu	—	1969
	Hilla	—	1969
	Dem Dima	—	1969
	Sahabad	—	1969
	Mohurgong & Gulma	—	1969

*Discontinued at end of 1969 season.

DARJEELING - WEST BENGAL

Project	Site	Index	Year of starting
N. P. K. Manuring	Tumsong	Dj 22	1965
	Sungma	Dj 23	1965
Nitrogenous Fertilizer	Marybong	Dj 28	1966
	Lingia	Dj 29	1967
	*Bannockburn	—	1968
	*Badamtam	—	1968
Pruning	Lingia	Dj 21	1963
	Phoobsering	Dj 24	1965
	Goomtee	Dj 25	1966
	Margaret's Hope	Dj 27	1966
Plucking	Mim	Dj 18	1961
Shade & Manuring	Nagri Farm	Dj 19	1961

*Discontinued after harvesting 1969 season crop.

Appendix-B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
by
THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Trial of biclonal seed stocks	South Bank, Assam	Hapjan	AS 200	1963
2.	,,	,,	Tengpani	AS 201	1963
3.	,,	,,	Tengpani		1965
4.	,,	,,	Kakajan	AS 206	1966
5.	,,	North Bank, Assam	Nahorani	AN 202	1963
6.	,,	,,	Sonabheel	AN 203	1964
7.	,,	,,	Durrung	AN 204	1965
8.	,,	,,	Bhooteachang	AN 205	1965
9.	,,	Cachar, Assam	Jellalpore	C 200	1963
10.	,,	,,	Dewan Group of Estates	C 201	1966
11.	,,	Dooars, West Bengal	Sathkyah	D 200	1962
12.	,,	,,	Bhatkawa	D 201	1962
13.	,,	,,	Bhatkawa	D 206	1965
14.	,,	,,	Hantapara	D 202	1964
15.	,,	,,	Meenglas	D 203	1964
16.	,,	,,	Hasimara	D 204	1964
17.	,,	,,	Rydak	D 205	1965
18.	,,	Terai, West Bengal	Hansqua	TR 200	1968
19.	,,	Darjeeling West Bengal	Mim	Dj 200	1961
20.	,,	,,	Ging	Dj 201	1965
21.	Effect of shade and nutrients	South Bank, Assam	Murmuria	AS 207	1965
22.	Observation plots	,,	Bazaloni		1962
23.	,,	,,	Abhoyjan		1969
24.	,,	,,	Duklingia		1963
25.	,,	North Bank Assam	Nonaipara		1966
26.	,,	,,	Budlapara		1967
27.	,,	Cachar, Assam	Chandighat		1969
28.	,,	Terai, West Bengal	New Chumta		1963
29.	,,	Dooars, West Bengal	Meenglas		1968
30.	,,	Darjeeling, West Bengal	Chongtong		1969
31.	,,	Sikkim	Kewzing		1969

ENTOMOLOGY DEPARTMENT

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Directional distribution of scarlet mite.	Darjeeling (West Bengal)	Balasun	N 7	1968
2.	Abundance of scarlet mite on pruned & skiffed tea.	Darjeeling (West Bengal)	Balasun	N 7	,,
3.	Distribution of scarlet mite under shaded condition.	Darjeeling (West Bengal)	Ging	N 7	,,
4.	Altitudinal distribution of scarlet mite	Darjeeling (West Bengal	Tukvar *	N 7	,,
5.	Seasonal cycle of scarlet mite or mite or large leafed & china hybrid bushes.	Darjeeling (West Bengal)	Chongtong	N 7	,,
6.	Red spider distribution on untouched tea.	Cachar (Assam)	Derby	N 7	,,
7.	Seasonal cycle of red spider on pruned teas on teela.	Cachar (Assam)	Serispore	N 7	,,
8.	Seasonal cycle of red spider on skiffed teas on teelas.	Cachar (Assam)	Aenakhal*	N 7	,,
9.	Indidence of scarlet mite in poor & well drained areas.	South Bank (Assam)	Bokahola	N 7	1967
10.	Distribution of scarlet mite on skiffed young & mature teas.	South Bank (Assam)	Bokahola	N 7	,,
11.	Seasonal incidence of shade tree nursery pests.	South Bank (Assam)	Duklingia	N 8	1970
12.	Distribution of shade tree nursery pests	South Bank (Assam)	Sycotta	N 8	1970
13.	Seasonal variation in the canker of shade tree	South Bank (Assam)	Bokahola & Sycota	N 8	1968
14.	Effects of weedicides on incidence of red spider.	South Bank (Assam)	Sotai	N 8	1969

	Experiment	Location of Estate	Site (T. E.	Index No.	Year started
15.	Weedicide effect on distribution of mites.	South Bank (Assam)	Katonibari	N 8	1970
16.	Termite activity following weedicide application	South Bank (Assam)	Dayang	N 8	1970
17.	Shade and manure effect on the ecology of mites.	South Bank (Assam)	Murmuria	N 7	1966
18.	Population cycle of red borer	North Bank (Assam)	Arun	N 7	1970
19.	Biology and distribution of termites under different agricultural operations	North Bank (Assam)	Tarajuli Addabarie Attarekhat Pertabghur Majulighur Hattigor	N 8	1970
20.	Seasonal cycle of scarmite on dark and light leaf jats.	Dooars (West Bengal)	Kalchini*	N 7	1968
21.	Distribution of scarlet mite under different agricultural operations	Dooars (West Bengal)	Ranicherra	N 7	1968
22.	Incidence of scarlet mite on pruned and skiffed teas	Dooars (West Bengal)	Telepara	N 7	1968
23.	Clonal susceptibility of red spider	Dooars (West Bengal)	Nagrakata	N 7	1969

*Experiments continued as long they were member of Tea Research Association.

MYCOLOGY DEPARTMENT

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	To study the effect of altering the conventional time of spraying against Red rust.	South Bank, Assam	Cinnamara	MR 001	1968
2.	To study the persistence of an oil based formulation and also to see the effect of spraying a standard formulation in divided doses and to compare it with the oil based one against Red rust.	,,	,,	MR 002	1968

	Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
3.	Screening of chemicals against Red rust.	,,	Dessoie	MR 004	1969
4.	Screening of fungicides against Black rot.	,,	Kakojan	MB 004	1969
5.	Comparison between the spraying efficiency of a power sprayer (Fontan) and the pressure retaining knapsack sprayer against Black rot.	North Bank,	Ghoirallie	MB 002	1968
6.	Effect of Potash manuring (Collaboration - West Bengal Adv. Dept) on control of Black rot.	Dooars West Bengal	Baradighi	MB 003	1967
7.	Effect of NPK manuring and - (Collaboration- Botany Dept.) on Black rot, Red rust and Poria.	South Bank Assam	Sungma	MC 002	1966
8.	N. P. K. Manuring and its effect (Collaboration - Darjeeling Adv. Br.) on incidence of Thorny blight	Darjeeling West Bengal	Sungma	MC 002	1966
9.	Screening of fungicide against-Thorny blight.	Darjeeling, West Bengal	Happy Valley	MC 001	1965
10.	Control trial with different fungicides against purple root rot.	North Bank, Assam	Baghmari	MP. 001	1965

PESTICIDE DEPARTMENT

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started.
1.	Joint action of acaricides (prophylactic) for control of red spider scarlet and purple mite.	South Bank, Assam	Bokahola	—	1969
2.	Joint action of acaricides (prophylactic) for control of red spider scarlet and pink mites.	,,	Teok	—	,,
3.	Joint action of acaricides and - insecticides (prophylactic) for control of red spider, scarlet mite scales.	,,	,,	—	,,

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started
4.	Joint action of acaricides (palliative) for control of scarlet, pink and purple mites.	,,	Dufflating	—	,,
5.	Joint action of acaricides and insecticides (palliative) for control of purple mite, scarlet mite and thrips.	Darjeeling	Balasun	—	1969
6.	Joint action of acaricides and insecticides (palliative) for control of red spider, scales and thrips.	,,	,,	—	,,
7.	Scale insect	,,	Springside	—	,,
8.	Blister blight	,,	Bloomfield	—	,,
9.	Cockchafer	Dooars	Dam Dim	—	,,
10.	*Agrilus beesoni* (No. 1)	South Bank, Assam	Haroocharai	—	,,
11.	*Agrilus beesoni* (No. 2)	,,	Kondoli	—	,,
12.	Red spider (prophylactic) (No. 1)	,,	Socklatinga	—	,,
13.	Red spider (prophylactic) (No.2)	,,	Haroocharai	—	1970
14.	Red spider (prophylactic) No.3)	,,	Gotoonga	—	1970
15.	Looper (No. 1)	,,	Amgoorie	—	1970
16.	Looper (No. 2)	,,	,,	—	1970
17.	Looper (No. 3)	,,	Borsillah	—	1970

STATISTICS DEPARTMENT

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Uniformity trial	South Bank, Assam	Bokahola	—	1963
2.	Uniformity trial	Darjeeling, West Bengal	Nagri Farm	—	1964
3.	Long term defoliation experiment	Dooars, West Bengal	Nya Sylee	—	1963
			Bhogotpore	—	1963
			Jiti	—	1963
			Hope	—	1963
			Kurti		1963

ENGINEERING DEVELOPMENT DEPARTMENT

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Continuous Fermenting Machine	South Bank Assam	Sycotta T.E.	E 3	From '69
2.	20"TCR Experiment at Heeleakah	-do-	Heeleakah	E 2	May '69
3.	Vertical Roller Experiment	Dooars	Gandrapara	E 2	May '68
4.	30" Disc Roller Experiment.	Darjeeling	Ging T. E.	E 2	Oct. '69
5.	48" Disc Roller Experiment	South Bank, Assam	Kharikatia	E 2	1969 upto Sept.'69
6.	48" Disc Roller Experiment.	North Bank, Assam	Nahorani T.E.	E 2	Sept. '69
7.	Manual Plucking Aid	Darjeeling	Rungli-Rungliot	E 8	1968
		Borbhetta, Assam	Soom T. E. Borbhetta		1968

Appendix - C

Published Papers and Papers in the Press

1. Banerjee, B. & Das, S. C. (1969). The effect of light on the oviposition rhythm of the tea red spider mite *Oligonychus coffeae* (Nietn.) *Bull ent Res.* **59** (2), pp. 371 - 376.

(Abs. The daily oviposition rhythm of the tea red spider mite, *Oligonychus coffeae* (Nietn.) under laboratory and field conditions is described. In the laboratory, the oviposition rate was steady under constant light or darkness, but under alternating light and darkness (LD 12 : 12 and 8:16) showed peaks soon after the change from light to darkness and *vice versa*. Under field conditions, oviposition peaks occurred at dawn and at dusk when there is a rapid change in light intensity.)

2. Banerjee, B. (1970). A mathematical model on sampling diplopods using pitfall traps. *Oecologia* **4**: pp102 - 105.

(Abs. Trapping of three species of diplopods, viz. *Cylindroiulus punctatus* (Leach), *Tachypodoiulus niger* (Leach) and *Polydesmus angustus* Latzel, with pitfall traps in areas with known densities follows a definite mathematical relationship. The number of each species trapped is density dependent upto a level : beyond that the increased density levels are not proportionately reflected in the catches. Ecological and mathematical implications of the observations are discussed.)

3. Barua, D. N. (1969). Seasonal Dormancy in Tea (*Camellia sinensis* L.) *Nature*, **224** (5218), pp. 514.

(Abs.Tea grown at or near the equator flushes throughout the year and produces approximately the same amount of crop every month, but away from the equator growth becomes seasonal and beyond 16° to 18° latitudes complete dormancy can be noted for a part of the winter. The length of the dormant period increases with latitude.

Having observed neither low temperature nor scarcity of water and nutrients in the soil to be the factors responsible for dormancy, short day length (or long night length) during winter was suspected to be the casual factor. To verify this hypothesis, pruned and unpruned mature tea bushes growing at Tocklai (26°47′) were exposed to 13 hour days during the winter by providing weak supplementary artificial illumination at dawn and dusk. Supplementary illumination enhanced shoot growth, hasened budbreak and inhibited flowering.

To test whether short-day induced dormancy is the result of a decrease in the relative concentration of gibberellic acid (GA) in the plant, young dormant plants were injected with 10 pp m. and 40 ppm GA December 30 (10 h 27 m). The injected plants promptly made one flush of growth before mid February when the untreated plants were completely dormant.

These results demonstrate that winter dormancy of tea is a matter of short days acting via the internal plant growth regulators, and open up the possibility of inducing growth under short-day conditions either by supplementary illumination or by treatment with GA.)

4. Sarkar, A. R. (1969). Use of double sampling in estimating the infestation of red-spider, *Oligonychus Coffeae* (Nietner), on the tea crop. *Indian J Agric. Sci.* **39** (8), August, pp. 854-859

(Abs. A double or 2 phase sampling technique is described for estimating the infestation of red spider, *Oligonychus coffeae* (Nietner), on the tea crop in the Dooars region of West Bengal during 1960. Double-sampling technique was very profitable in estimating its infestation and for the same cost the mean infestation was estimated with 50 per cent more precision than with single sampling. However, adoption of optimum double-sampling scheme may increase the precision by 63 per cent over single sampling. The possible gains due to optimum double sampling over single sampling for the estimation of infestation of a pest under different circumstances for the same cost are discussed.)

5. Banerjee, B. Oviposition and eclosion rhythms of *Andraca bipunctata* Wlk. *Ind. J. Ent.* (communicated)

6. Banerjee, B. Theoretical models on predator-prey relationships in arthropods. *Proc. zool. Soc.* (communicated)

7. Barua, D. N. A review of light as a factor in metabolism of the tea plant (*Camellia sinensis* L.) *Proc. Symp. Long Ashton.* (communicated)

8. Barua, P. K. Flowering Habit and Vegetative Behaviour in tea *Camellia sinensis* L.) Seed Trees in North East India. *Ann. Bot.* (communicated)

Appendix - D

Summary of meteorological observations during 1969

Table 1, Tocklai (Mid Assam) Latitude : 26°47′ N. Longitude : 94°12′E; Altitude : 86.6 metres a. m. s. l.

Month 1969	Daily temperature °C					Rainfall		Daily sun shine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
									Depth			Open Pan in mm	Penman in mm
	Mean max	Mean min.	Mean	Highest	Lowest	Rainfall in mm	Day with 0.03 mm and above		5cm	15cm	30cm		
January	22.6	9.0	15.8	24.6	6.3	31.8	5	6.8	18.2	17.4	18.4	41.0	62.7
	(22.4)	(9.2)	(15.8)			(21.1)	(5)	(5.8)	(18.9)	(18.3)	(19.0)		
February	25.2	11.9	18.6	28.4	7.7	2.4	2	7.5	21.2	20.0	20.3	59.4	87.0
	(24. 1)	(11.8)	(18.0)			(32.1)	(7)	(6.1)	(20.7)	(19.8)	(20.2)		
March	28.2	16.8	22.5	32.5	12.8	76.5	12	6.4	24.8	23.4	23.5	85.3	126.8
	(27.5)	(15.4)	(21.4)			(82.6)	(11)	(6.6)	(24.1)	(23.0)	(23.0)		
April	30.2	19.9	25.0	33.8	18.4	230.6	16	7.3	28.0	26.0	26.6	114.5	156.7
	(28.7)	(18.9)	(23.8)			(190.7)	(17)	(5.9)	(27.0)	(25.8)	(25.6)		
May	31.2	22.8	27.0	35.2	19.5	89.2	15	6.9	30.6	29.2	28.9	105.5	175.1
	(29.9)	(21.7)	(25.8)			(283.0)	(20)	(5.0)	(28.6)	(27.6)	(27.5)		
June	31.7	24.8	28.2	36.2	22.5	248.8	19	4.2	31.3	30.2	30.2	95.3	144.4
	(31.5)	(24.1)	(27.8)			(323.9)	(23)	(4.4)	(30.6)	(29.5)	(29.3)		
July	32.2	25.5	28.8	35.1	24.2	351.2	28	4.8	31.8	30.8	30.7	102.3	160.2
	(32.2)	(24.5)	(28.4)			(386.3)	(25)	(4.8)	(31.4)	(30.4)	(30.4)		
August	31.4	24.7	28.0	35.4	23.0	282.8	26	4.8	31.0	30.6	30.6	93.7	151.3
	(32.0)	(24.5)	(28.2)			(338.7)	(23)	(5.0)	(31.5)	(30.5)	(30.5)		
September	31.9	24.5	28.2	34.6	22.8	309.2	11	6.9	31.6	30.5	30.6	88.2	152.4
	(31.2)	(23.8)	(27.5)			(254.9)	(19)	(5.0)	(31.0)	(30.2)	(30.2)		
October	29.9	21.2	25.6	32.6	17.8	38.8	8	7.2	28.7	28.2	28.6	70.5	126.3
	(29.3)	(20.9)	(25.1)			(115.5)	(12)	(5.6)	(28.5)	(28.0)	(28.2)		
November	26.2	16.1	21.2	30.0	11.8	28.7	6	5.5	24.0	23.8	24.6	43.1	77.1
	(26.2)	(15.1)	(20.6)			(26.9)	(4)	(6.1)	(24.1)	(23.6)	(24.6)		
December	24.1	11.1	17.6	26.7	6.0	2.1	2	6.6	20.0	19.8	20.9	35.8	61.4
	(25.4)	(10.6)	(18.0)			(10.3)	(3)	(5.9)	(20.1)	(19.8)	(20.8)		

Note :- (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Per cent Relative humidity

Table : 1(a) Tocklai

Hours of Observations I. S. T.	Jan.	Feb.	March	April	May.	June	July	August	Sept.	Oct.	Nov.	Dec.
0613	95	92	92	90	88	89	92	92	94	96	96	97
	(97)	(95)	(93)	(91)	(93)	(93)	(94)	(94)	(95)	(97)	(97)	(97)
1313	52	42	50	54	65	75	77	74	69	65	63	58
	(58)	(55)	(54)	(62)	(71)	(75)	(75)	(75)	(74)	(72)	(64)	(61)

Note :- Data in brackets show previous averages

Summary of meteorological observations during 1969

Table : 2, Silcoorie (Cachar) Latitude : 24° 50′ N; Longitude : 92°48′ E; Altitude : 39.6 meters a. m. s. l.

Month 1969	Daily temperature °C					Rainfall		Daily sun shine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Rainfall in mm	Day with 0.03 mm and above		Depth			Open Pan in mm	Penman in mm
									5cm	15 cm	30 cm		
January	25.1	10.3	17.7	29.1	8.1	16.3	4	8.0	20.8	19.9	20.8	61.1	76.1
	(26.0)	(10.9)	(18.4)			(20.6)	(2)	(8.0)	(21.8)	(20.8)	(21.4)		
February	28.4	11.4	19.9	33.5	7.8	0.0	0	9.0	23.7	22.2	22.3	90.1	106.8
	(27.4)	(12 7)	(20.0)			(46.6)	(4)	(8.0)	(23.3)	(22.2)	(22.4		
March	31.4	17.0	24.2	34.1	11.2	169.0	8	8.5	27.4	26.0	26.0	129.8	155.6
	(30.6)	(16.5)	(23.6)			(104.3)	(8)	(7.9)	(26.8)	(25.4)	(25.4)		
April	32.0	20.4	26.2	35.2	17.3	313.7	12	7.6	29.2	28.2	28.0	126.6	166.3
	(32.3)	(20.5)	(26.4)			(219.6)	(12)	(7.8)	(29.7)	(28.2)	(28.1)		
May	33.6	23.4	28.5	37.6	19.4	194.9	13	8.5	32.7	31.2	30.9	146.3	200.4
	(31.9)	(22.8)	(27.4)			(398.8)	(19)	(6.5)	(30.6)	(29.4)	(29.3)		
June	31.8	24.5	28.2	35.3	21.6	709.2	21	4.6	31.0	30.2	30.1	113.6	148.1
	(31.5)	(24.4)	(28.0)			(610.9)	(24)	(4.0)	(30.5)	(29.6)	(29.4)		
July	32.7	25.2	29.0	35.8	23.7	506.3	26	5.3	31.8	30.9	30.8	111.6	162.8
	(32.2)	(25.0)	(28.6)			(538.5)	(27)	(4.5)	(31.4)	(30.5)	(30.4)		
August	31.5	24.6	28.0	34.8	23.0	495.4	26	4.2	30.7	30.2	30.2	?	141.3
	(32.1)	(24.9)	(28.5)			(428.4)	(25)	(4.8)	(31.4)	(30.5)	(30.6)		
September	33.5	24.9	29.2	36.5	22.4	41.4	9	7.8	31.5	31.0	31.1	?	167.4
	(32.4)	(24.6)	(28.5)			(327.4)	(17)	(5.7)	(31.2)	(30.4)	(30.4)		
October	31 8	22.2	27.0	34.9	19.3	123.4	5	7.3	29.4	29.0	29.2	85.0	137.3
	(31.2)	(22.3)	(26.8)			(208.8)	(10)	(6.6)	(29.4)	(28.8)	(29.0)		
November	29.0	17.0	23.0	33.1	10.1	35.0	3	7.0	25.8	25.6	26.2	63.3	96.2
	(29.3)	(17.0)	(23.2)			(16.3)	(2)	(8.0)	(25.9)	(25.4)	(26.0)		
December	27.2	12.4	19.8	28.7	8.6	0.0	0	7.9	23.0	22.4	23.2	58.6	81.6
	(27.0)	(12.6)	(19.8)			(8.2)	(1)	(7.9)	(22.8)	(22.4)	(23.0)		

Note :- (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.
(iv) ? indicates data not available.

Per cent Relative humidity
Table : 2(a) Silcoorie

Hours of observations I. S. T.	Jan.	Feb.	March	April	May	June	July	August	September	Oct.	Nov.	Dec.
0619	99	97	93	93	91	96	95	96	93	97	98	99
	(98)	(96)	(93)	(90)	(91)	(95)	(95)	(95)	(95)	(97)	(97)	(98)
1319	46	31	46	58	58	78	74	78	62	61	56	47
	(46)	(43)	(43)	(54)	(67)	(76)	(75)	(74)	(71)	(67)	(55)	(48)

Note :- Data in brackets show previous averges.

Summary of meteorological observations during 1969

Table 3. Nagrakata (Dooars) Latitude : 26° 54' N Longitude 82° 55' E, Altitude : 228.6 meters a. m. s. l.

Month 1969	Daily temperature °C					Rainfall		Daily sun shine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Rainfall in mm	day with 0.03 mm and above		Depth 5 cm	Depth 15 cm	Depth 30 cm	Open Pan in	Penman in mm
January	23.7	9.7	16.7	25.5	5.9	28.0	3	8.0	18.0	18.4	19.4	81.4	71.4
	(23.7)	(10.5)	(17.1)			(11.2)	(2)	(8.2)	(18.0)	(18.0)	(19.4)		
February	25.5)	12.5	19.0	29.9	7.7	3.1	2	8.1	20.8	20.4	20.8	100.3	94.7
	(25.7)	(13.2)	(19.4)			(22.3)	(3)	(7.6)	(20.1)	(19.6)	(20.6)		
March	29.5	17.5	23.5	34.0	13.2	97.8	8	7.1	25.1	24.4	24.4	148.6	138.5
	(29.1)	(16.2)	(22.6)			(48.1)	(5)	(7.8)	(23.6)	(23.0)	(23.4)		
April	31.4	20.0	25.7	34.9	16.0	78.7	13	8.1	27.6	26.8	26.6	169.2	172.3
	(31.4)	(20.0)	(25.7)			(109.8)	(9)	(7.3)	(26.9)	(26.2)	(26.5)		
May	31.3	21.3	26.3	34.9	15.9	364.5	23	7.2	28.6	27.6	27.8	165.7	178.4
	(30.9)	(21.7)	(26.3)			(291.6)	(20)	(6.6)	(28.4)	(27.6)	(28.0)		
June	31.0	23.2	27.1	36.0	20.1	722.7	25	4.6	29.2	28.3	29.2	132.0	147.9
	(30.4)	(23.3)	(26.8)			(898.3)	(26)	(3.8)	(28.5)	(28.0)	(28.2)		
July	(31.0	23.9	27.4	33.9	23.0	825.0	27	4.4	29.6	28.5	29.8	104.5	148.2
	(30.3)	(23.7)	(27.0)			(1048.5)	(27)	(3.4)	(29.0)	(28.2)	(28.6)		
August	29.9	23.7	26.8	34.2	22.8	756.8	27	3.0	28.9	28.0	29.2	96.8	122.0
	(30.5)	(23.7)	(27.1)			(774.6)	(28)	(4.1)	(29.3)	(28.8)	(29.0)		
September	30.6	23.0	26.8	33.7	20.2	369.7	16	5.1	28.8	28.0	29.1	110.9	132.0
	(30.6)	(22.8)	(26.7)			(536.7)	(22)	(5.3)	(29.0)	(28.9)	(28.8)		
October	30.1	18.6	24.4	33.5	14.9	97.2	9	9.0	26.8	27.0	27.6	116.2	139.1
	(29.8)	(19.3)	(24.6)			(192.5)	(10)	(7.9)	(26.7)	(27.2)	(27.2)		
November	26.5	15.3	20.9	30.9	11.5	7.7	5	7.3	23.1	23.7	24.6	74.0	85.9
	(27.2)	(14.5)	(20.8)			(13.5)	(3)	(8.6)	(22.5)	(22.7)	(24.0)		
December	25.0	11.6	18.3	25.8	7.1	0.0	0	8.4	20.3	20.9	22.0	79.1	74.1
	(24.8)	(11.6)	(18.2)			4.1)	(2)	(8.4)	(19.4)	(19.7)	(21.0)		

Note :- (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface

Per cent relative humidity

Table : 3 (a) Nagrakata

Hours of observations I. S. T.	Jan..	Feb.	Mar.	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
0634	87	82	81	73	84	96	95	97	92	87	89	83
	(83)	(80)	(74)	(75)	(87)	(95)	(96)	(96)	(95)	(88)	(84)	(86)
1334	53	48	54	55	66	81	83	82	76	61	59	49
	(51)	(50)	(46)	(52)	(70)	(83)	(84)	(82)	(78)	(67)	(58)	(54)

Note :- Data in brackets show previous averages

Summary of meteorological observations during 1969

Table 4. Nagri Farm (Darjeeling) Latitude : 26°55′N; Longitude. 88°12′ E; Altitude : 1158.2 meters a. m. s. l.

Month 1969	Daily temperature °C					Raihfall		Daily sun shine in hours	Daily soil temperature (under grass) °C			Monthly	
	Mean max.	Mean min	Mean	Highest	Lowest	Rainfall in mm	Day with 0.03 mm and above		Depth			Open Pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	14.5 (15.4)	7.4 (7.9)	11.0 (11.6)	17.6	4.5	3.6 (21.6)	2 3)	6.0 (6.6)	13.8 (13.0)	12.5 (12.5)	14.2 (13.9)	44.1	54.3
February	16.0 (16.9)	9.3 (9.7)	12.6 (13.3)	21.9	6.8	6.1 (18.0)	2 (3)	5.9 (6.1)	15.7 (14.6)	13.6 (13.8)	15.1 (14.5)	51.6	70.1
March	21.4 (20.7)	14.0 (12.7)	17.7 (16.7)	24.6	10.0	69.1 (65.2)	10 (5)	6.0 (6.7)	20.2 (18.5)	18.0 (17.1)	18.6 (17.3)	99.6	116.3
April	24.5 (23.4)	16.3 (15.8)	20.4 (19.6)	27.9	13.5	51.1 (80.7)	7 (9)	6.9 (6.0)	22.8 (21.7)	20.2 (20.2)	20.7 (20.1)	117.8	145.4
May	23.5 (23.8)	17.4 (17.2)	20.4 (20.5)	29.3	12.7	352.8 (189.5)	21 (18)	5.3 (5.4)	23.7 (23.6)	21.7 (22.1)	22.2 (22.0)	85.6	138.6
June	24.6 (23.9)	19.1 (18.8)	21.8 (21.4)	29.6	18.4	322.5 (413.1)	27 (25)	6.0 (2.8)	25.4 (24.4)	23.4 (23.4)	23.8 (23.2)	71.4	140.7
July	24.9 (23.9)	21.3 (19.2)	23.1 (21.6)	27.1	18.3	538.9 (674.2)	27 (27)	2.8 (2.4)	25.5 (24.7)	23.7 (23.6)	24.4 (23.7)	64.5	116.7
August	24.1 (24.6)	19.0 (19.1)	21.6 (21.8)	27.1	17.7	379.0 (501.6)	27 (26)	2.2 (3.2)	25.5 (25.1)	23.6 (24.0)	24.6 (24.1)	48.7	101.7
September	24.3 (24.3)	18.1 (18.3)	21.2 (21.3)	27.4	15.0	293.6 (309.5)	17 (20)	4.0 (4.1)	24.6 (24.2)	22.8 (23.4)	23.8 (23.6)	62.9	106.4
October	23.5 (23.0)	15.4 (15.4)	19.4 (19.2)	26.4	13.7	41.9 (148.4)	5 (8)	7.6 (6.8)	23.1 (21.8)	21.2 (21.0)	22.4 (21.6)	76.4	111.3
November	20.5 (19.7)	12.4 (11.5)	16.4 (15.6)	24.7	9.3	3.1 (13.4)	3 (2)	5.8 (7.1)	18.8 (17.8)	17.4 (17.2)	19.4 (18.5)	45.2	77.5
December	17.8 (17.4)	9.6 (9.2)	13.7 (13.3)	20.1	7.7	0.0 (3.3)	0 (1)	6.5 (6.9)	15.2 (14.6)	14.8 (14.0)	16.2 (15.6)	41.9	57.8

Note :- (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afte rnoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Per cent relative humidity
Table : 4(a) Nagri Farm

Hours of observations I. S. T.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
0637	66 (71)	67 (70)	65 (65)	63 (68)	80 (80)	91 (92)	93 (94)	93 (94)	86 (89)	71 (77)	74 (69)	72 (71)
1337	68 (70)	64 (67)	63 (62)	63 (67)	82 (82)	87 (89)	85 (91)	87 (88)	83 (87)	75 (80)	75 (74)	69 (72)

Note :- Data in brackets show previous averages.